ACM 2017

ASIAN CONFERENCE ON METEOROLOGY 2017 (ACM2017)

S1E Presentation

S1E-1

Southern Hemisphere zonal-mean circulation changes from Last Glacial Maximum (LGM) to Future Climate

Seo-Yeon Kim (Seoul National University)
Seok-Woo Son (Seoul National University)

The recent studies have shown that the westerly jet and Hadley-cell (HC) edge in the Southern Hemisphere (SH) have systematically shifted poleward during the last few decades. These trends are qualitatively well reproduced by climate model simulations, and further projected to continue in future climate. However, it is unclear whether opposite trends hold in paleoclimate when global surface air temperature was much colder than present climate. To better understand zonal-mean circulation change in a wide range of climate states, the present study compares the westerly jet and HC edge in the Last Glacial Maximum (LGM), the latest cold period of the Ice Ages about 21,000 years ago, Pre-Industrial (PI) condition, and Extended Concentration Pathway 4.5 (ECP4.5) by analyzing coupled model simulations archived for the Paleoclimate Modelling Intercomparison Project phase 3 (PMIP3) and the Coupled Model Intercomparison Project phase 5 (CMIP5). Only SH circulations, which can be largely explained by zonal-mean dynamics, are considered in equilibrium state of each model simulation. In all six models analyzed in this study, HC edge systematically shifts poleward from LGM to PI then to ECP4.5 conditions. However, jet latitude presents non-robust changes. Although all models exhibit a poleward shift of westerly jet in a warm climate as in HC edge change, they show mixed responses in a cold climate. Only three models show equatorward jet shift, whereas other three show the jet moving poleward in LGM condition. This large intermodel spread in jet-latitude change is closely related with uncertainty in tropical upper-tropospheric temperature change. By integrating a dynamic core GCM with imposed tropical upper-tropospheric warming or cooling, it is shown that a systematic poleward shift of zonal-mean circulation in a warm climate but nonsystematic change in a cold climate can be largely explained by quasi-geostrophic zonal-mean dynamics. It is particularly shown that weakened subtropical static stability due to upper tropospheric cooling extends baroclinic zone equatorward, resulting in a broader baroclinic zone than control case. This allows baroclinic eddies develop over broader latitudinal bands, introducing an uncertainty in eddy-driven jet latitude.

S1E-2

Understanding Severe Winter Haze Pollution in the North-Central North China Plain in 2014

Zhicong Yin (Nanjing University of Information Science and Technology)
Huijun Wang (Nanjing University of Information Science and Technology)

Atmospheric pollution has become a serious environmental and social problem in China. The number of winter (December-February) haze days over the North China Plain (WHDNCP) was largest in 2014 during the past 30 years. In addition to anthropogenic influence, the roles of climate anomalies were also vital. Thus, it is necessary to analyse the anomalous atmosphere circulations associated with haze pollution of this year in detail. Near surface, the weaker East Asian winter monsoon pattern, inducing southerly over North China Plain, could aggravate the situation of haze. In the lower and middle troposphere, taking the anti-cyclone circulation over North China as an intermedia, the positive phases of the East Atlantic/West Russia (EA/WR), the Western Pacific (WP) and the Eurasia (EU) patterns led to a worse air pollution dispersion condition that contributed to a larger number of WHDNCP. In 2014, these three patterns could be recognized from the wind anomalies in the lower troposphere. The preceding autumn (September-November) Arctic sea ice (ASI) anomalies over the Eastern Hemisphere and the warmer winter surface over Eurasia might have induced or intensified the positive EA/WR pattern in 2014. These two external forcings, together with the pre-autumn sea surface temperature anomalies in the Pacific, might have also stimulated or enhanced the positive EU-like patterns. The anomalous surface temperature in autumn 2014 was efficient in intensifying anomalous circulations such as the positive phase of the WP pattern. The opposite case of minimum WHDNCP in 2010 further supports the mechanism of how EA/WR and WP patterns and associated external factors altered the local climate conditions to impact the WHDNCP.

S1E-3

Role of spring and summer phytoplankton under greenhouse warming to Arctic amplification by biophysical feedback in Earth System Model

Hyung-Gyu Lim (Pohang University of Science and Technology)
Jong-Seong Kug (Pohang University of Science and Technology)

Phytoplankton pigments in the ocean absorbs visible wavelengths of solar irradiance to utilize photosynthesis. In aspect of ocean, chlorophyll concentration change, phytoplankton mass, affects penetration of shortwave radiation in global ocean surface layer. Modulation of attenuation and the extinction of solar radiation through the ocean by considering chlorophyll enhances heating rate within ocean column. Investigating the oceanic biophysical processes is receiving attention as a new parameter of determining strength of air sea and biological interaction and their impacts in climate system. In the recent study, it has been proved that biophysical feedback enhances faster Arctic warming and Arctic amplification under greenhouse warming. The Arctic climate is significantly sensitive to mean change of chlorophyll concentration. While role of chlorophyll in Arctic is mainly focused on mean change, role of chlorophyll year-to-year variability is not comprehended. Firstly, we investigate a role of chlorophyll interannual variation to the Arctic climate. Fully-interactive CM2.1 earth system model is conducted. Non- interactive experiment of chlorophyll is also conducted but prescribed by the chlorophyll climatology of the fully-interactive experiment. Both experiments is fixed at 352.7 ppm CO_2 concentration level at the state of 1990 year. The main result of comparison between interactive and non interactive experiments is showing that the Arctic chlorophyll interannual variability induces relatively cold condition in the Arctic. The cause of cold response associated with chlorophyll interannual variation is sensitivity of absorption rate depending on interactive or non interactive chlorophyll. The covariance between sea ice and chlorophyll concentration is asymmetric due to different limiting condition, spring is positive and summer is negative. The summer sea ice and chlorophyll variabilities are stronger than spring, therefore, the cooling effect is relatively dominant. This relationship between sea ice and phytoplankton variability reduces absorption of solar radiation. In addition, the absorption and extinction of solar radiation is nonlinear depending on increasing or decreasing chlorophyll concentration. In case of absorption rate of shortwave radiation, decreasing chlorophyll effect is larger than increasing chlorophyll effect. As a single result, the cause is investigated due to ice-phytoplankton coupling and shortwave extinction coefficient non-linearity. Secondly, greenhouse warming experiment until doubled CO_2 by increasing CO_2 1%/year are conducted by using fully-interactive run of CM2.1 earth systems. Under greenhouse warming, the CM2.1 earth system model is simulating chlorophyll increase in spring but chlorophyll decrease in summer. In addition to mean change of chlorophyll, ice-phytoplankton coupling strength in the model is changed that spring strength is induced and summer strength is reduced by sea-ice melting due to increased long-wave radiation. It is suggesting that amplified Arctic warming by phytoplankton is not only contributed by impact of chlorophyll mean in spring but also chlorophyll interannual variability. To evaluate the contribution of the Arctic amplification associated with chlorophyll change, five scenarios of the Arctic chlorophyll concentration change are conducted to evaluate the Arctic climate sensitivities by using CM2.1 Earth System Model. Comparing CM2.1 Earth System Model experiments to test Arctic warming sensitivity are found: Future chlorophyll mean changes induce Arctic warming (CC2-CC1). Future chlorophyll interannual variation induces warm condition of Arctic (BGC.on-CC2). Spring chlorophyll increasing trend induces Arctic warming (PCS1-CC1). Summer chlorophyll decreasing trend induces Arctic cooling (PCS2-CC2). Shortwave extinction coefficient non-linearity induces weak cold Arctic (PC-CC2). Consequently, this study suggests that amplified Arctic amplification by bio-geophysical feedback has been responding to both warming effects of spring chlorophyll increase and ice-phytoplankton coupling strength decrease.

S1E-4

Correlation and Anti-Correlation of the East Asian Summer and Winter Monsoons during the Last 21,000 Years

Xinyu Wen (Peking University)

What are the relations between East Asian summer (EASM) and winter (EAWM) monsoons during the last 21,000 years? The Asian summer and winter monsoons are the most important climate variability over East Asia. Its response to future climate change is of great societal interest but still remain highly uncertain. Traditionally, the scientists suppose EASM and EAWM behave oppositely (anti-correlation). But recent new evident suggest that EASM and EAWM experience positively correlated evolution in the last thousands of years. The conflict viewpoint challenge the physical interpretation of current climate projection. This work aims to answer the key question regarding the long-term co-variability of EASM and EAWM since Last Glacial Maximum (LGM), so that improve scientific understanding of the monsoon dynamics and help improving its projection over East Asia.

We would present the results from a comprehensive modeling study of an interesting problem in monsoon dynamics: the co-evolution feature of the East Asia summer and winter monsoons. With a full set of long-term transient climate model simulations of the last 21,000 years, using the National Center for Atmospheric Research (NCAR) Community Climate System Model (CCSM) version 3, we are able to fulfill the gap between those observations by providing an unified interpretation framework in understanding historical monsoon variability. Our study, for the first time, demonstrate that the correlation between the EASM and EAWM depends on two key physical processes at distinct time scales. On the long-term orbital timescale, EASM and EAWM are positively correlated with a simultaneous strengthening during the deglaciation and weakening during the Holocene in response to Northern Hemisphere mid-latitude solar radiation forcing associated to the orbital parameter precession. On the fast-varying millennial timescale, the EASM and EAWM are negatively correlated, in particular during the deglaciation, mainly forced by the melting water pulses into the North Atlantic. Furthermore, the greenhouse gases and ice sheet forcing also play minor roles for the monsoon correlation and tends to cancel out after deglaciation, suggesting the relatively minor role of greenhouse gases (GHGs), as compared to Atlantic meridional overturning (AMOC), in modulating Asian monsoons in current and future global warming scenario.

Our findings challenge the traditional view of the monsoon's correlation/anti-correlation in paleoclimate community, and synthesize new emerging evident in Asia and surrounding counties. We presents a new and unified framework in understanding the long-term evolution of East Asian summer and winter monsoons, which benefit current monsoon related climate projection in the future.

Reference

1. Wen, X., Z. Liu, S. Wang, J. Cheng, and J. Zhu: Correlation and anti-correlation of the East Asian summer and winter monsoons during the last 21,000 years. Nature Communications, 2016, 7, 11999. doi:10.1038/ncomms11999
2. Wen, X., Z. Liu, Z. Chen, E. Brady, D. Noone, Q. Zhu, and J. Guan: Modeling precipitation d18O variability in East Asia since the Last Glacial Maximum: temperature and amount effects across different time scales. Clim. Past, 2016, 12, 2077-2085.
3. Liu, Z., X. Wen, E. C. Brady, B. Otto-Bliesner, G. Yu, et al.: Chinese cave records and the East Asia Summer Monsoon. Quat. Sci. Rev., 2014, 83, 115-128.
4. Guan, J., Z. Liu, X. Wen, E. C. Brady, D. Noone, J. Zhu, and J. Han: Understanding the temporal slope of the temperature-water isotope relation during the deglaciation using isoCAM3. Journal of Geophysical Research, 2016, 121(17).

S1E-5

Irrigation enhances local warming with greater nocturnal warming effects than daytime cooling effects

Xing Chen (Southern University of Science and Technology)
Sujong Jeong (Southern University of Science and Technology)

To meet the growing demand for food, land is being managed to be more productive using agricultural intensification practices, such as the use of irrigation. Understanding the specific environmental impacts of irrigation is a critical part of using irrigation as a sustainable way to provide food security. However, our knowledge of irrigation effects on climate is still limited to daytime effects. This is a critical issue to define the irrigation effects on warming related to greenhouse gases (GHGs). This study shows that irrigation led to an increasing temperature (0.005℃/year) by enhancing nighttime warming (0.016℃/year) more than daytime cooling (-0.007℃/year) during the dry season from 1961 to 2014 over the North China Plain (NCP), which is one of largest irrigation areas in the world. By implementing irrigation processes in regional climate model simulations, the consistent warming effect of irrigation on nighttime temperatures over the NCP was shown to match observations. The intensive nocturnal warming is attributed to the energy storage in the wetter soil during the daytime, which contributed to the nighttime surface warming. Our results suggest that irrigation could amplify the warming related to GHGs, and this effect should be explicitly integrated into future climate change projections.

S1E-6

Differences of the Silk Road Pattern between early and late summer

Xiaowei Hong (Institute of Atmospheric Physics, Chinese Academy of Sciences)
Riyu Lu (Institute of Atmospheric Physics, Chinese Academy of Sciences)
Shuanglin Li (Institute of Atmospheric Physics, Chinese Academy of Sciences)

The Silk Road Pattern (SRP), which manifests as the leading mode of the upper-tropospheric meridional wind anomalies in summer, is a well known teleconnection pattern in mid latitude. It is featured by alternative southerly and northerly wind anomalies along the summer Asian westerly jet, and therefore exerts great influences on the local climate along its path.

Our recent investigation identified that the SRP presents distinct features between early and late summer with the subseasonal change of the Asian westerly jet. It is more westward displaced with about 10° in longitudes in late summer relative to early summer. On the other hand, the SRP in late summer explains much greater variance of the upper-tropospheric meridional wind anomalies in mid latitude but seems less significant over East Asia, when compared with that in early summer. We further explored the underlying mechanisms using the atmospheric dynamics.

S1E-7

Impacts of the Spatio-temporal Variation of Temperature Sensitivity of Soil Respiration on the Terrestrial Carbon Fluxes using Carbon-Nitrogen Cycle

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

Soil decomposition process in terrestrial ecosystem is one of critical components in control for global carbon cycling and prediction global warming. Temperature sensitivity of soil respiration (Rs) called Q10 values in soil decomposition process is uniform and unchangeable in the numerical description that generally tends to be spatio-temporal heterogeneity in the observation. In this study, we conducted the new parameterization of Q10 variation associated with soil respiration and major physical variables such as soil temperature and moisture using multiple regression using the observation data and investigated the impacts of new parameterization of Q10 variation on the terrestrial carbon cycle. Our results show that ununiform spatial distribution of Q10 enhanced heterogeneous anomaly of soil respiration comparing with default simulation. Moreover, it tends to improve simulation of the relationship between soil respiration and two major physical variables over cold and dry regions reasonably.

The simulated global gross primary production (GPP) bias was also reduced comparing with FLUXNET-MTE. Moreover, the underestimation of GPP over high latitude regions (60～80N) was significant improved about two times than simulation with constant Q10 value globally. The realistic Rs and GPP simulation induced to represent carbon balance between release at the subsurface and uptake at the surface over terrestrial biosphere reasonably. Overall, enhanced heterogenous temperature sensitivity in the soil decomposition process in the model showed the improvement of soil carbon release and uptake. We suggested that the important of realistic soil decomposition process will be able to simulate the responses of carbon-climate feedback with realistic soil carbon release under climate change scenarios.