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S1&S2E Presentation

S1&2E-1

Anthropogenic aerosol effects on East Asian winter monsoon: The role of black carbon induced Tibetan Plateau warming

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This study investigates anthropogenic aerosol effects on East Asian winter monsoon (EAWM) with Community Atmospheric Model version 5. In winter, the anthropogenic aerosol optical depth is the largest over southern East Asia and adjacent oceans. The associated EAWM change, however, is the most significant in northern East Asia, which is characterized by a significant surface cooling in northern East Asia and an acceleration of the jet stream around 45°N, indicating an intensification of the EAWM northern mode. Such an intensification is attributed to anthropogenic black carbon (BC) induced Tibetan Plateau (TP) warming. The BC is mostly transported from northern South Asia by wintertime westerly and southwesterly, and then deposited on snow, giving rise to a reduction of surface albedo and an increase of surface air temperature via the snow-albedo feedback. The TP warming increases meridional temperature gradient and lower-tropospheric baroclinicity over northern East Asia, leading to the jet stream acceleration around 45°N and the westward shift of East Asian major trough via the transient eddy-mean flow feedback. Such upper-tropospheric pattern favors more cold air outbreak, leading to a large surface cooling in northern East Asia. In southern East Asia, the effect of non-absorbing aerosols is dominant. The solar flux at surface is significantly reduced directly by scattering of non-absorbing aerosols, and indirectly by intensification of short wave cloud forcing. Accordingly, the surface air temperature in southern East Asia is reduced. The precipitation is also significantly reduced in South China and Indo-China Peninsula, where the aerosol indirect effect is the largest.

S1&2E-2

Bayesian Variability Model Averaging for Red Noise Systems

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Previous Bayesian approaches to weighting multiple models in a computer model ensemble break important new ground, but they neglect model skill at capturing variability and short-term memory of the system. Since present-day variability may be related to the magnitude of future climate change, the variability may be an important (yet so far neglected) constraint on the models. Here we present a novel method, Bayesian Variability Model Averaging, to weight models by their skill not just at trend, but also at variability and short-term memory of an underlying red noise process. The key idea is separating model output into trend and variability components. The weights are first assigned separately for each component, and are then combined under an assumption of independence. Weighting the trend sub-models is performed following prior work. This procedure accounts for uncertainty in internal variability, as well as for model error. For the variability sub-models, a correlated model error is assumed between the best model red noise parameters (innovation standard deviation and autocorrelation), and the parameters of the true climate. The variability sub-model weights are then obtained using Monte Carlo integration. Future predictions account for internal variability (using either bootstrapping or simulating from red noise auto-correlated processes), as well as for model error.

We perform cross-validation of the new method on several datasets, and compare it to a trend-only weighting method. The datasets include: Atlantic Meridional Overturning Circulation (AMOC), temperature-based AMOC Index, East Japan Sea winter mean temperature, and Korean summer mean maximum temperature. All datasets use a subset of Climate Model Intercomparision Project phase 5 (CMIP5) climate models. The exercises include assuming each model to be representative of the “true” climate one-at-a-time. We weight the models using the “true” model’s output as pseudo-observations. Then, we exclude the “true” model from the set, and compare the projections from the remaining models with the “truth”. We optimize a parameter related to model error to achieve approximately correct coverage of the 90% posterior prediction intervals for each method and dataset. For the AMOC Index we use an additional validation procedure. It involves using a subset of historical observations to weight the models, and then observations from a subsequent historical period to validate the weighted projections.

We find considerable relationships between present-day variability properties, and future climate change for some datasets. The new method’s best model error can be up to two times smaller compared to the trend-only method. This signifies that the new method may have a larger power to separate good from poor models. Moreover, variability weighting tends to improve projections, based on the average 90% posterior credible intervals, and mean absolute bias.

Finally, we apply both methods to a real case of projecting summer mean maximum temperatures in Korea. Specifically, we use 29 CMIP5 climate models, which we weight by the 1973-2005 observations from the Korean Meteorological Agency (KMA). The mean change increases from 4.9 K to 5.7 K under the trend+variability method, while the low tail of the projections gets considerably cut off. The mode increases substantially from 5.2 K to 6.6 K under the new method. Likewise, we also report an increase in the median (from 5.0 K to 6.0 K).

We discuss the caveats of the new approach, and potential new areas for its applicability.

S1&2E-3

A positive feedback process between tropical cyclone and moisture conveyor belt assessed from Lagrangian diagnostics

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To construct a new conceptual tropical cyclone (TC) model from a macroscopic view, we have examined a positive feedback process between the intensity of a prototypical TC (i.e., Typhoon Man-yi 2007) and the moisture conveyor belt (MCB) that has been suggested by previous researches. We performed SST sensitivity experiments, using a cloud resolving regional model with a spatial resolution of 0.05o longitude by 0.05o latitude, and made forward and backward trajectory analyses for Man-yi to evaluate how air parcels related to latent heat release intrude into the TC inner core region through the MCB and to verify whether such a feedback process operates efficiently. We also conducted a non-existence TC run to confirm that a TC can trigger the MCB formation under the background monsoon westerlies and investigated another TC (Halong 2002) to validate that the TC-MCB feedback is applicable to other western North Pacific TCs.

The forward and backward trajectory analyses based on a real SST experiment (CNTL run) exhibit that air parcels gain a large amount of moisture from the underlying ocean while those are transported by the MCB and results in releasing latent heating within the TC inner core region in a few days. The SST sensitivity experiments that modified the observed SST field over the Indian Ocean and the South China Sea reveals that the TC intensity tends to be strong (weak) at its mature stage when the MCB is well (ill) organized. The same results were also derived from the simulations for Halong (2002), implying that Man-yi is not an extraordinary case. Enhancement of the MCB facilitates the transport of very humid air parcels to the vicinity of the TC via the MCB, leading to active intrusion of those parcels into the TC inner region through the atmospheric boundary layer due to the inflow of radial wind relevant to the secondary TC circulation. Since the increase in latent heating released by those parcels, in turn, intensifies the radial inflow within the boundary layer, the TC can gain more parcels with abundant water vapor from the remote ocean. The non-existence TC run could not trigger the MCB formation in comparison with the CNTL run because the westward phase propagation of equatorial Rossby waves induced by the TC heating that interacts with the background monsoon westerlies is indispensable for its formation. These results increase the reliability of the TC-MCB feedback.

S1&2E-4

Three approaches for statistical prediction of non-Gaussian climate extremes

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Prediction of climate extremes is challenging, especially for non-Gaussian extremes, since the Gaussian assumption used in traditional linear regression is violated. Three approaches are introduced for statistical prediction of non-Gaussian climate extremes in this presentation. (1) The first one uses a multiple linear regression model after transforming the non-Gaussian predictant to a quasi-Gaussian variable when the predictant does not deviate from Gaussian distribution too much, and uses Pearson's correlation test to identify potential predictors (Qian et al. 2015). (2) The second one uses a generalized linear model when the transformation is difficult and uses a nonparametric Spearman's correlation test to identify potential predictors (Qian et al. 2015). (3) With the help of the first-order difference (year-to-year increment), the difference series is more likely a Gaussian distribution than it was in the original series and is thus used as the predictant to find predictors and to construct a prediction model by using traditional linear regression. The difference is first predicted and is then added to the observed value of the target variable at the preceding time to obtain the final prediction result. This method can take the urbanization effect into account and is thus suggested for statistical prediction of climate extremes in urban areas (Qian et al. 2017). The non-Gaussian annual occurrence of hot days and hot nights at Macau and Hong Kong are used to illustrate the three approaches.

S1&2E-5

Role of intraseasonal oscillation in the persistent extreme precipitation over the Yangtze River Basin during June 1998

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The persistent extreme precipitation event (PEPE) that occurred over the Yangtze River Basin (YRB) during the period of 12-27 June 1998 is the most severe one in recent 60 years, and it is mainly caused by two significant components of intraseasonal oscillation (ISO) (10-30 days and 30-60 days) identified in this study. The two ISOs play different roles in the distributions of YRB rain belt in the PEPE; i.e., the 30-60 day ISO generally maintains the shape and intensity of YRB rain belt with its peak covering the whole PEPE period; however, the 10-30 day ISO mainly determines the south-north swing of the YRB rain belt that features three PEPE stages. North Indian Ocean is the major forcing region of 30-60 day ISO, where anomalous warm sea surface temperature-induced local strong convections stimulate a meridional teleconnection wave train over the East Asia, generating the 30-60 day intraseasonal YRB rainfalls. The 10-30 day ISO primarily originates from the northwest Pacific and the South China Sea (SCS), and along with its northwestward and northeastward propagations due to the air-sea coupling and prevailing winds, suppressed and enhanced convections appear alternatively over the Philippine Sea and the central SCS in the three PEPE stages; thus, their stimulated downstream wave trains along the coast of East Asia vary accordingly in terms of phase and position, causing three stages of 10-30 day intraseasonal YRB rainfalls with different intensities and locations. These results suggest that proper combination of different intraseasonal oscillations is one of the essential and effective ways to produce the PEPEs.

S1&2E-6

Predicting Rainy Season Onset in Thailand based on Boreal Summer Intraseasonal Oscillation Forecasts

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Thailand located in the Indochina Peninsula in the Southeast Asia is one of the world's largest rice exporters, but rain-fed agriculture is a common practice in many parts of Thailand. Therefore annual crop yield in Thailand is predominantly dependent on rainfall variability. Dominated by southwest monsoon bringing humid air from Indian Ocean towards Indochina Peninsula, the rainy season in Thailand starts from mid-May and lasts until October. The onset of the rainy season is important for the agricultural sector to make irrigation schedule, however, the onset time of the rainy season vary from year to year making farmers difficult to manage agricultural water systems. The Boreal summer intraseasonal oscillation (BSISO) refers to the convectively coupled northward as well as eastward/westward propagating disturbance in boreal summer and is known to play an important role in modulating the onset of summer monsoon in many parts of Asia. Capitalizing on the multi-model hindcasts hosted in WMO World Weather Research Programme (WWRP)-World Climate Research Program (WCRP) subseasonal-to-seasonal (S2S) Project's data archive, this study shows that BSISO forecast can be utilized to predict rainy season onset date in Thailand with lead times up to 4 weeks.

S1&2E-7

Evaluation of CMIP5 Model Performance for the Rainy Season Evolution Over East Asia and the Future Change

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The East Asian monsoon is a subsystem of the Asian-Pacific monsoon and shows lower reproducibility in models than the other monsoon subsystems Therefore, the performance of the monsoon simulation is an important indicator in assessing progress in climate modeling.

This study evaluates CMIP5 model performance on rainy season evolution in the East Asian summer monsoon. Historical (1986-2005) simulation is analyzed using ensemble mean of CMIP5 19 models. Simulated rainfall amount is underestimated than the observed and onset and termination of rainy season are earlier in the simulation. Compared with evolution timing, duration of the rainy season is uncertain with large model spread. This area-averaged analysis results mix relative differences among the models. All model show similarity in the underestimated rainfall, but there are quite large difference in dynamic and thermodynamic processes. The model difference is shown in horizontal distribution analysis.

It's estimated from pattern correlation and normalized standard deviation. A measure of skill score S for seven variables is calculated. Rank the models by averaging of varables's skill score and 5 models are selected for each High and Low skill score group.

Contrast to the observations, models simulated rainband movement is weak due to the underestimated rainfall amount. But when we divided into High and Low Skill model, relatively High skill models capture well north ward seasonal march of the rain belt and pattern correlation higher than MME, Low skill models. Models rain band in Aprill/May appears slightly shifted to the north of the observed.

Simulated Raiband shift northward than the observarion gives influence on the simulated onset timing. In model simulation Onset to the south of 25°N tends to be delayed than the observed and the onset to the north of 25°N comes early on all models. To understand of northward shift in model simulation, we examine thermodynamic analysis.

Compared to obs, Models' 335K of equivalent potential temperature boundary appear shifted to the north than the obs and is strong. then, simulated rain-belt is stronger than obeservation on north of 25N. Comparing High and Low skill model, High skill model simulate equivalent potential temperature gradient stronger than in Low skill model. Therefore rainband northward movement simulated better in High skill group than in Low skill group. In addition low-level circulation for evolving frontal system is quite well captured in High group.

According to RCP8.5, CMIP5 projects earlier onset, delayed termination and longer duration of the rainy season with increasing rainfall amount at the end of 21st century.

For the rainy season evolution timing, High and Low skill models shows similarity in future change. Atmospheric condition such as North pacific high and southerly also show similarity in both skill models. However, the difference between High and Low skill models is shown in thermodynamic structure. High and Low in future projection are the subsequent unstable changes in the conditional instability. Low skill model the instability is expected to be larger than in High skill model. The different change of instability between High and Low skill model seems to be related to larger amount in heavy rainfall. And our future plan is to investigate whether the larger amount in heavy rainfall in Low skill model could be related to the model spread in future precipitation projection.

S1&2E-8

Variability of Climate Extremes in Nepal

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In Nepal, climate extremes are increasingly becoming more pronounced and devastating in nature, and account for more than half of the total economic and human losses due to natural disasters every year. Thunderstorms, floods, heavy rainfall (resulting in landslides), hailstorms, windstorms, snowstorms, droughts, heat waves and cold waves are the most common climate induced disasters occurring in different seasons and regions. Climate change and its spatial variability can be related to the intensity and frequency of extreme events. This study endeavors to address the research gap on spatial and temporal variability of temperature and precipitation extremes across Nepal. Thorough studies are needed to understand the comprehensive status of observed climatic extreme events during 1970-2015. In this study, a total of 20 climate extreme indices of temperature (10) and precipitation (10) as recommended by the World Meteorological Organization (WMO) were calculated by using RClimDex software for 90 meteorological stations. The data were analyzed using the Mann-Kendall test and Sens' slope method to identify significant trends and magnitude for each index at each station.

The results showed that the frequency, intensity and duration of temperature and precipitation related extreme events are increasing in almost all regions and seasons. However, the number of cold nights and days are decreasing in almost all seasons and regions with the exception of sporadic localized increasing trend in western mountainous region during winter. Similarly, most of the regions experienced no change or a slightly decreasing trend of consecutive wet days, but these trends are not statistically significant. Annual precipitation showed a decreasing trend, but nevertheless some isolated parts of the Siwalik and Terai regions showed a significant increase. Very wet and extreme wet precipitation is higher increase in western Terai and Siwalik regions compared to other regions; however it is decreasing in mid-mountain regions. The 1-day extreme precipitation is significantly increasing in the Siwalik and mid-mountain regions but the 5-day precipitation trend showed a north-south contrast with an increasing in northern region and a decreasing trend in southern regions. The frequency of very intense precipitation days (>100 mm/day) are increasing for last few decades with highest magnitude in Terai and Siwalik regions.

The average temperature is significantly increasing throughout the country showing intensification of warming with altitude and more pronounced in high altitude and western parts. The maximum temperature trend is generally higher than the minimum temperature trend. The noticeable feature of temperature is that the highest increasing trend of winter maximum temperature in all mountainous regions but a concurrent decreasing trend in low lying Terai plains. Consistent with this is a significant negative trend for the monthly minimum value of daily maximum and minimum temperature in some parts of Terai and mid-mountain regions, in which prolonged foggy conditions may be speculated as the cause in Terai regions. The number of tropical nights is increasing with its intensification with altitude. The last decade is the warmest period during the last 4 decades with the year 2010 ranked as the warmest year in the record and 2011-2015 is the period experiencing consistent warming during the study period.

Overall, most of the hot (warm days, warm nights, summer days, tropical nights, and warm spells, etc.) and cold (cold days, cold nights, cold spells, etc.) extreme indices showed significant positive and negative trends respectively. However, extreme precipitation indices also have an increasing trend, but the statistical significance and spatial coherence is low. It can be concluded that the findings of this analysis is evidence of climate change in Nepal. The results provide reliable information for understanding climate change and will useful for planning and management of disasters and climate adaptation programs in Nepal.

Key words: Climate extremes, Nepal, extreme precipitation indices, temperature indices, RclimDex