# ACM 2017

# ASIAN CONFERENCE ON METEOROLOGY 2017 (ACM2017)

## S2B Presentation

S2B-1 (Invited Talk)

# Simulation and analysis of convective weather hazards

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For this presentation, we will discuss recent efforts to produce and analyze reliable information regarding convective weather hazards and the potential impacts of climate change in the Midwestern United States. Potential alterations of average and extreme conditions in the future climate could significantly affect a wide range of interconnected systems that impact this region, such as: agriculture, energy consumption/generation, water resources, infrastructure, health, and ecosystems. In order to properly assess these impacts, especially for those sectors that are sensitive to extreme weather and climate events, detailed spatial and temporal information is required. Due to this coarse resolution and parameterization of physical processes, GCMs are unable to properly depict smaller-scale circulation features, such as mesoscale convective systems. GCMs have also been severely limited in their ability to represent realistic surface heterogeneities that can have a large impact on local/regional climate, such as inland lakes, coastlines, terrain, and land use/land cover specification. These issues have necessitated the development and application of downscaling techniques which generally fall into two categories: statistical and dynamical downscaling. Statistical downscaling approaches are often used to correct biases and spatially downscale the information provided by coarse-resolution GCMs. Dynamical downscaling approaches typically involve higher-resolution simulations over a regional domain that are driven by output from GCMs. We will discuss recent results from dynamical downscaling using convection-allowing models (CAMs) which are promising tools to generate process-based climate information on small scales, where deep convection can be simulated explicitly and the representation of land-atmosphere interactions is significantly improved. Results from a recent effort led by the Purdue Climate Change Research Center and ideas for future research will be discussed at the conference.

S2B-2

# Trend of Deep Convective Activity in the Tropics in 110-yr ERA-20C Reanalysis Dataset

Tetsuo Nakazawa (Meteorological Research Institute, JMA)

It is easily understood that the global warming give us more chance of hotter summer days. But is it also true that we may have more heavy rainfall events under the global warming scenarios? Such extreme events, especially related with clouds or convection, can be attributed to the global warming? One of the key words would be “atmospheric stability/instability”. The model result shows in the future projection, that the atmosphere will become more stable, not unstable due to the warming in the upper troposphere. Then why do we have more severe events in the warming planet? It is puzzling and controversial. As the state-of-art simulation models contain uncertainty in estimating such extreme events in the future projection, I decided to use the historical data in the past to see if there is a trend in the atmospheric stability or convective activity.

The data I used is the reanalysis dataset, provided by the European Centre for Middle-range Weather Forecasts(ECMWF), called “ERA20C” (http://apps.ecmwf.int/datasets/data/era20c-moda/levtype=pl/type=an/), which covers the gridded data from 1900 to 2010 globally. The dataset is regridded with 1.5 deg x 1.5 deg horizontal resolution.

Using Arakawa and Schubert’s spectral representation of cumulus convection, the cloud properties, such as the fractional entrainment rate of each cloud sub-ensemble, and the moist static energy in each cloud sub-ensemble, are diagnostically determined from the large-scale field of and in the reanalysis dataset. The total number of cloud types is 26 and the cloud base is 950 hPa. We follow the same method as Lord(1982) used to define the moist static energy in each cloud sub-ensemble at the cloud base. To calculate the fractional entrainment rate, we used the following “virtual temperature” correction equation to lose the buoyancy at the detrainment level, originally described in Arakawa and Schubert’s paper in 1974.

The result shows that there is a weaker trend of the deep convective activity in the tropics, due to the stabler condition in the atmosphere and implying that this result supports the tendency of the reduction of the global number of tropical cyclones.

S2B-3

# Future changes in precipitation over East Asia projected by the global atmospheric model MRI-AGCM3.2

**Shoji Kusunoki** (Meteorological Research Institute, JMA)

We conducted global warming projections using global atmospheric models with high-horizontal resolution of 20-km (MRI-AGCM3.2S, the 20-km model) and 60-km (MRI-AGCM3.2H, the 60-km model) grid sizes. For the present-day climate of 21 years from 1983 through 2003, models were forced with observed historical sea surface temperatures (SST). For the future climate of 21 years from 2079 through 2099, models were forced with future SST distributions projected by the models of the Fifth phase of Couple Model Intercomparison Project (CMIP5). Ensemble simulations for four different SST distributions and three different cumulus convection schemes were conducted to evaluate the uncertainty of projection.

The simulations consistently project the increase of precipitation over eastern China for almost all months. In June, precipitation decreases over Japan and increases over the ocean to the south of Japan. The geographical distribution of precipitation change tends to depend relatively on the cumulus convection scheme and horizontal resolution of models rather than on SST distributions. The time evolution of pentad mean precipitation over Japan indicates the delay in the onset of Japanese rainy season in June. This delay can be attributed to the decrease of water vapor transport toward Japan associated with the southward shift of the subtropical high. Change in the subtropical high can be interpreted as the southward shift of the local Hadley circulation. The intensity of precipitation increases over most part of East Asia, while the possibility of drought will increase over Japan, the East China Sea and the area to the south of Japan.

S2B-4

# Role of convective precipitation in the relationship between sub-daily extreme precipitation and temperature

**In-Hong Park** (Pohang University of Science and Technology)
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The intensity of extreme precipitation is expected to increase with temperature at a rate consistent with the available moisture, which is determined by the Clausius-Clapeyron (C-C) relation. The C-C rate is approximately 6-7%°C-1, and is found to largely hold for observations and model simulations. However, on a sub-daily timescale, the intensities of extreme precipitation are observed to increase with temperature at a rate exceeding water vapor constraints. This so-called 'super C-C' scaling has been suggested to occur due to (1) the statistical effect which involves the transition of precipitation types from stratiform to convective events, and (2) the physical effect by which convective process itself can overcome the thermodynamic limitation.

This study examines these two mechanisms for the super C-C relationship using in situ observations from 26 stations over South Korea during the recent 35 years, focusing on the role of convective events. The characteristics of sub-daily precipitation scaling with changes in temperature are investigated by considering four timescales (hour to day) and the dependence of scaling on precipitation type is analyzed. Scaling results show that hourly extreme precipitation undergoes a transition from a C-C rate to a super C-C rate at around 20°C, supporting the statistical effect. The transition temperature observed in Korea is, however, much higher than European regions (12°C), which seems to be due to the climatologically low frequency of convective events in Korea than in Europe. Nevertheless, the threshold fraction of convective precipitation when the scaling transition starts to occur is found to very similar between two regions as around 0.2, indicating the important role of convective events in shaping the scaling. The fraction of the convective rainfall increases rapidly with temperature, contributing more to the total precipitation scaling as temperature rises, which seems to induce a scaling transition. This scaling transition and the contribution of the convective precipitation found in Korea are generally similar to those reported in other regions. On the other hand, convective extreme precipitation alone exhibits a super C-C scaling at temperatures above 12°C, while the scaling slope for stratiform extreme precipitation follows the C-C rate, suggesting that the physical effect is also at work in Korea.

In addition, the scaling shows a robust peak-like shape with maximum precipitation intensity near 24°C with a positive relation at low temperatures and then a transition to a negative relation at high temperatures, as in other mid-latitude regions. This is different from the C-C relation in which, as the temperature increases, relative humidity should remain constant and specific humidity should increases following the moisture availability. Our analyses of humidity show that above 24°C, relative humidity decreases significantly and specific humidity levels off. This suggests that considerable changes in humidity, i.e. moisture limitation, weakens the precipitation scaling at high temperatures, mechanisms for which need to be further examined in the future work.

S2B-5

# Evaluation of East Asia Regional Reanalysis with ERA-Interim and in situ observations during 2013-2014

**Eun-Gyeong Yang** (Yonsei University)
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A reanalysis is a high-quality climate data set that represents the best estimate of the atmospheric state, which is produced by assimilating long time series of observations with a consistent and state-of-the-art NWP model and DA system. The reanalysis data as scientific information for continuous economic growth has become more important because various industries depend on weather and climate data. Up to now, most reanalysis consist of the global reanalysis. Since the coarse resolution (approximately 100 km) of the global reanalysis provides little value in industrial fields, spatially more detailed data are required. Hence, many meteorological organizations in North America, Europe, the Arctic, and South Asia have started or plan to produce regional reanalyses with higher resolution. However, no regional reanalyses exist for East Asia.

In order to represent detailed characteristics of climate over East Asia, a system for producing East Asia Regional Reanalysis (EARR) based on the Korea Meteorological Administration (KMA)'s operational 12-km resolution Unified Model (UM) has been developed. By 6-hourly cycling 4DVAR with a 6-hour assimilation window, EARR is produced 4 times a day (00, 06, 12, 18 UTC) for 2 years (2013-2014). Analysis and forecast fields from KMA's operational 25-km resolution global version of UM are used as lateral boundaries for EARR.

Because reanalysis is the estimate of the true atmospheric state, evaluation of reanalysis is required. Thus, in this study, the characteristics of the EARR are examined compared to ERA-Interim (ERA-I) reanalysis and observations. Compared to ERA-I, in terms of skill scores, the EARR performance for wind, temperature, relative humidity, and geopotential height improves except for mean sea level pressure, the lower-troposphere geopotential height, the upper-air relative humidity. Similarly, RMSEs of the EARR are smaller than those of ERA-I for wind, temperature, and relative humidity, except for the upper-air meridional wind and the upper-air relative humidity in January. With respect to the near-surface variables, the triple collocation analysis and the correlation coefficients confirm that EARR provides a much improved representation compared to ERA-I. In addition, EARR reproduces the fine-scale features of near-surface variables in greater detail than ERA-I and the kinetic energy (KE) spectra of EARR agree more with the canonical atmospheric KE spectra than ERA-I KE spectra. Based on the fractions skill score, the near-surface wind of EARR is statistically significantly better simulated than that of ERA-I for all thresholds, except for the higher threshold at smaller spatial scales.

Therefore, although special care needs to be taken when using the upper-air relative humidity from EARR, the near-surface variables of the EARR developed are found to be more accurate than those of ERA-I. To address these difficulties, the advanced methods used for producing other reanalysis products can be recommended to be applied in producing the EARR for a longer period. For example, the variational bias correction (VarBC), cloud assimilation, and precipitation assimilation could be applied.

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