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S1&S2D Presentation

S1&2D-1

Recent climate extremes: What's predictable and what's not

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Increasing weather and climate extremes have resulted in tremendous loss of life and property worldwide. Record-breaking extreme heat and precipitation events are steadily growing, driving a significant surge of academic interest in projection and attribution analyses. Emerging new theories regarding the increased weather/climate extremes present an exciting new development in science; however, newly proposed mechanisms can contradict each other or be overgeneralized. Controversial theories (such as one-way vs. two-way Arctic warming effects) can confuse the public and concerned stakeholders who are not familiar with meteorology. Likewise, over-generalized concepts do little to advance the prediction of extreme events. This presentation highlights the different pathways that climate mechanisms engender extreme events and harnesses that information to improve extreme event prediction. This presentation illustrates recent flood events in North America, including the 2017 California flood (that dramatically reversed the unprecedented drought), 2016 Louisiana flood (that rivals Hurricane Katrina), 2015-2016 Texas floods, 2016 West Virginia flood (a 1-in-1000-year event), and the successful story of predicting the great 2011 Missouri River flood. This talk is designed to be inclusive of the diverse theories by (a) integrating the different views and approaches in research of climate extremes and, (b) transitioning the systematically acquired scientific knowledge to benefit the potential in forecasting from a meteorological perspective.

S1&2D-2

Anthropogenic impacts on recent decadal change in temperature extremes over China: Relative roles of greenhouse gases and anthropogenic aerosols

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Observational analysis indicates significant changes in some temperature extremes across mid-1990s over China. The hot extremes are characterized by an increase in annual hottest day temperature (TXx) and warmest night temperature (TNx), and an increase in frequency of summer days (SU) and tropical night (TR) after mid-1990s. The cold extremes are distinguished by an increase in annual cold day temperature (TXn) and coldest night temperature (TNn), and a decrease in frequency of ice days (ID) and frost days (FD) since mid-1990s. These decadal changes in temperature extremes not only exhibit over China as a whole, but also over individual climate sub-regions.

Coupled climate model (specifically an AGCM coupled to an ocean mixed layer model) forced by changes in anthropogenic greenhouse gases (GHG) concentrations and anthropogenic aerosol (AA) emissions reproduced the general pattern of observed changes in temperature extremes, which suggests the pronounced role of anthropogenic forcing changes in the observed decadal change. Furthermore, the experiments with separate forcings indicate that GHG forcing dominates the increase of temperature extremes. In response to the GHG forcing, the increase of clear sky downward longwave radiation and shortwave cloud radiation, being associated with decease of cloud cover, contributes to the surface warming over eastern and southern of China. The positive downward latent heat flux, being consistent with reduced evaporation, results in the surface warming over northwestern China. The results imply that the increase in temperature extremes over China since mid-1990s is most likely to be sustained or amplified in the near term when the GHG concentrations will continue to rise.

S1&2D-3

Consecutive Droughts of the Indian Summer Monsoon

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In this work we investigate primary mechanisms leading to consecutive droughts over India using observations and reanalysis products. There have only been four consecutive droughts (1904-1905, 1965-1966, 1986-1987, & 2014-2015) over India during the past 120 years. While each of the four consecutive droughts had at least one strong El-Nino associated with them, the 1986-1987 consecutive drought was associated with a persistent El-Nino that affected the Indian Summer Monsoon (ISM) during both years. Analysis shows that both due to teleconnections as well as local effects there are associated changes in other monsoon features such as the mean sea level pressure (MSLP) over the monsoon trough region, the upper troposphere tropical easterly jet (TEJ) over the Indian region, and the upper troposphere subtropical westerly jet (SWJ) stream that are not favorable for the ISM. For example, many of these drought years show a southward incursion of the SWJ that weakens the Tibetan anticyclone, leading to a weaker Hadley circulation that is conducive to sustain break-like conditions of the ISM.

S1&2D-4

Development and evaluation of heat-wave warning system for South Korea based on Limited Area Ensemble Prediction System (LENS)

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With recent extreme heat wave events in South Korea, there is an increasing demand on effective heat wave warning system. Currently, severe weather warnings at Korean Meteorological Administration (KMA) are issued based on Model Output Statistics (MOS) of deterministic model Regional Data Assimilation and Prediction System (RDAPS) with horizontal resolution approximately 11 km x 11 km. Generally numerical modeling systems suffer by uncertainties which may lead to false alarm or miss detection of the severe weather events. Ensemble prediction systems (EPS) deal with these uncertainties by providing several scenarios for same forecast period. The EPS can be then used as base for probabilistic forecast of severe weather events such as heat waves, cold spells, wind gust etc. Recently, the KMA runs a Global EPS (EPSG) with 32 x 32 km and Limited Area EPS (LENS) with 3 x 3 km spatial resolution. The main goal of the research was to develop a real-time probabilistic ensemble based heat wave warning system for South Korea using LENS. Besides the development of the source code, the system was evaluated using statistical analysis methods, and the results were considered in reconfiguration of the system for operation use. The final products are risk maps, grid-point probability maps and area probability maps. The system computes daily maximum temperature for 3 days ahead. Then the probabilities are derived by calculating the fraction of ensemble members which pass a given daily maximum temperature threshold. Thresholds were decided upon epidemiological evidence of thermal morbidity and mortality as well as climatological data and model performance. The risk maps are based on 4 x 4 weather impact matrix with maximum daily temperature categories as impact on the x-axis, and probability categories as likelihood on the y-axis. Model evaluation results show, that the LENS tends to underestimate the maximum daily temperatures. Particularly, the 35°C threshold, which is currently used by KMA to issue the heat-wave warning, shows highest RMSE and worst reliability. Therefore, the threshold for the upper category of the maximum daily temperature was reconsidered with respect to the forecast error. The probability thresholds were decided upon reliability diagram. Since the LENS tends to underestimate the daily maximum temperature, a lower probability thresholds were used, thus even at small probability the system will trigger the particular warning. The maximum air temperature seems to have systematic error and can be later fixed using proper bias correction method. Overall, the system is usable for forecasting heat wave impact on human health and can be used alongside existing warning system. In the future studies we plan to examine and apply several bias corrections to improve the system accuracy. Moreover, to consider other important variables such as relative humidity, solar radiation and wind speed in the heat-wave impact forecast, we plan to extend the system products by perceived temperature based risk maps.

S1&2D-5

Mapping heat-stress hazard, vulnerability, and risk in Seoul

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Background: Heat stress threatens human health, particularly in the cities. For understanding and reducing the adverse impacts of heat stress on human health in the cities, heat-stress maps are important. A broad approach to heat-stress impact assessment considers three components: hazard, vulnerability, and risk. Often, however, only hazard, vulnerability, hazard+vulnerability or hazard+risk are analyzed, instead of all three components together. Considering all the three components would allow an evaluation of the concept by examining the statistical relationships between hazard, risk, and vulnerability. The aim of this study is to (1) identify the spatial pattern of heat-stress hazard, vulnerability, and risk in the megacity of Seoul, Republic of Korea, and (2) to evaluate our heat-stress impact assessment concept. Hence, we will test if the districts in Seoul with high heat-stress vulnerability and hazard are indeed the districts with high heat-stress risk.

Methods: We analyzed the summers of the years 2000 to 2013, while summer 2015 and 2016 served for the evaluations. The term heat-stress hazard relates to a physical event with a specific intensity and magnitude that may cause damage to human health. We represent heat-stress hazard by air temperature and mean radiant temperature for an average heat day and we simulated the temperature with numerical and geo-statistical models for the whole city of Seoul. Heat-stress vulnerability describes the sensitivity and exposure to an adverse effect and depends on the socio-economic, health-related, and/or the demographic factors. We calculated a heat vulnerability index (HVI) for each district. Heat-stress risk describes the potential or the probability of an adverse health effect from heat. We applied heat-related mortality to represent the risk in each district. A time-series (2000-2013) of air temperature served to establish the linear regression models with heat-related excess mortality.

Results: With the help of the three maps, we identified the vulnerable, hazardous, and risky districts in terms of heat stress in Seoul. We demonstrated that heat-stress risk, vulnerability, and hazard are spatially heterogeneous in Seoul at a district scale. All three components tend to show higher values in the central districts of Seoul, rather than in the outer ones. Nevertheless, large differences exist between the spatial patterns of heat-stress hazard, vulnerability, and risk. Thus, the correlation between heat-stress risk, vulnerability, and hazard was weak. This implies that the concept is not completely consistent in the given setting because the districts with the highest heat-stress hazard and vulnerability were not the ones with the highest heat-stress risk.

Conclusions: Our study indicates that it is important to examine more than one component of the heat-stress impact assessment to get a comprehensive perspective on the possible hot spots in the cities. It is essential because heat-stress hazard, vulnerability, and risk show differing patterns and do not substitute each other. Moreover, the spatial information on the three elements of heat stress may help to improve early warnings and plans by targeting on specific tasks in each district. For example, the districts with high hazard should concentrate on the measures to reduce the urban heat island, such as greening and shadowing. While in the districts with high vulnerability, the focus should be on the vulnerable subgroups, e.g. providing cool shelters for the economically weaker people or offering special care for the seniors and the diabetes patients.

S1&2D-6

Estimation of urban maximum and minimum air temperatures using multitemporal MODIS satellite data

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Maximum and minimum air temperatures (Tmax and Tmin, respectively) in urban areas are considered significant variables for numerous urban issues including heat wave, urban heat island effect, air pollution, and human mortality. As a large city has a variety of infrastructures with a large population, minute temperature changes in the area notably affect the human and natural environment. Therefore, identifying the spatial and temporal pattern of urban air temperature is quite important. However, deficient weather observations in cities can limit the understanding of temperature patterns in heterogeneous areas. In addition, approximately three-quarters of the cities in the world are close to coastlines, making interpolation of station-based temperature data difficult. Many studies have focused on using remote sensing-derived land surface temperature (LST) to estimate air temperature with various methods. Few studies, however, have estimated air temperature using remote sensing by focusing solely on urban areas. This study suggested a novel approach using a random forest machine learning to estimate daily Tmax and Tmin using multitemporal land surface temperatures in two sites (Seoul, South Korea and Los Angeles (LA), United States) which have different summer climates. We used eight time-series LST products (4 times a day and 4 times a day before) from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard Terra and Aqua satellites, with seven auxiliary variables including solar radiation, normalized difference vegetation index (NDVI), elevation, latitude, longitude, aspect, and the percentage of impervious area. We found there are different relationships between each of the eight time-series LSTs with Tmax and Tmin for the two sites, and developed eight schemes using different combination of LST variables as inputs. The best schemes showed an R2 of 0.728 and 0.770 and an RMSE of 1.1℃ and 1.2℃ for Tmax and Tmin in Seoul and an R2 of 0.850 and 0.777, and an RMSE of 1.7℃ and 1.2℃ for Tmax and Tmin in LA, respectively, from 10-fold cross-validation results. Tmax values, in particular, showed a high degree of relevance to geographic factors such as sea breeze and mountains of the two sites, while Tmin measurements showed more distinct temperature differences between impervious and vegetated areas in the two sites. The research findings from this proposed approach deserve further studies focusing on prediction of daily maximum and minimum temperatures through the synergistic use of satellite data and forecast model output.