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Poster Presentation

Session 2 [P-056~P-115]

P-056

Drought identification using actual evapotranspiration based on the Bouchet hypothesis

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The actual evapotranspiration (AET) is closely related to atmospheric moisture demand and surface water availability and thus indicates drought conditions, while drought is normally defined as precipitation deficiency. In this study, we combined AET estimated from the Bouchet hypothesis with the structure of the Standardized Precipitation-Evapotranspiration Index (SPEI) to propose a fully ET-based drought index, namely the Standardized Evapotranspiration Deficit Index (SEDI). We found that SEDI, without using precipitation data, was temporally consistent with the Palmer Drought Severity Index (PDSI) and the Standardized Precipitation Index (SPI) in the south-central United States. It was also found that SEDI was of competitive performance to indicate agricultural droughts based on its strong correlation with the Vegetation Health Index (VHI). We suggest that SEDI from the ET deficit is useful as a proxy of agricultural drought in regions with strong coupling between land surfaces and the atmosphere.

P-057

How Graphic Design can be used to change audience perception of weather data and improve it's communicative capacity

Philippe Jean (York University)

In today's world, access to news and information is more convenient than ever. People can easily obtain regular updates on relevant data they want and need. Some of this information is vital because it allows specialized groups or individuals to make key decisions that can have a major impact on the lives of others.

The discipline of graphic design has an important role to play in developing how information is conveyed and consumed. Based on my thesis research, this oral presentation will focus on how weather content can be displayed alternatively, both graphically and visually, and ultimately allow richer data interpretations from users.

As explained by Dr. Jeffrey T. Nealon, professor of English and philosophy at Penn State University, the weather often functions as a privileged figure for banality itself; the lingua franca of everyday speech (Nealon, 2013, 109).

The research of T. Nealon provides a framework for observing weather content as something that is: banal, due to excessive visibility; necessary, as it allows viewers them to make informed decisions within their daily lives; and socially relevant, as it allows us to connect due to its universal acceptability.

Adding to these characteristics, the typical way of displaying weather data-the inclusion of mass amounts of information with low metric variation in a static neutral visual structure preconceived for a specific media- participates in reinforcing its perception as banal information. It is thus fundamental to start observing that content from a different angle in order to highlight the critical impact it has on our lives.

Through the analysis of visual projects focused on alternative representation of weather data conducted in the context of my Master of Design at York University, Toronto, Canada, I will discuss how design can be used to change the perception of weather data through the use of alternative forms of visual representation. This investigation as a whole participated in challenging the perception of weather information as banal information (perception caused by several factors, such as neutral and conventional display, overrepresentation in the media, etc.).

The content used inside this research was used as a starting point for the generation of various, interesting visual solutions, highlighting its incredible richness in the data. As a result, while I still perceive that weather information can be banal, generally due to its pervasive presence in everyday life, I observed that this same content has originality and dynamic value when combined with engaging visual representations.

As such, my presentation will demonstrate not only how weather data can be communicated and perceived differently through non- traditional forms of data visualization, but also the importance of orienting the visual representation of such a quantitative content towards a more qualitative and individualized form.

As a professional designer and a design educator, I strongly believe that graphic design has the potential to participate in establishing an original relationship between the weather content and its visual display, counter- acting the perceived banality of weather data by fostering a rich, engaging, and surprising experience. In the context of the Asian Conference on Meteorology, I aim to stimulate an open dialogue and initiate questioning surrounding the ways in which the representation of weather content can draw the public's attention and participate in improving its comprehension of the subject.

P-058

The study of Sea Fog invasion in Qingdao: Monitoring and Character

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Sea fog is composed of small liquid water droplet or ice crystal reducing the visibility to less than 1km over the ocean, when sea fog lands on the coast it can further influence safety of land traffic, airport, agriculture and so on. Qingdao, located in the north part of Yellow Sea, is well known as the one of the most important port city along the China Sea, is also influenced a lot by the sea fog. Especially, in the Yellow Sea fog season from April to July, sea fog often lands on coast and invades into the inland, paralyzing the land traffic and airport. Then improving the capacity of sea fog monitoring becomes more important for the weather forecast service and fog research. In the past, due to less meteorology stations, researchers mainly rely on satellite data to retrieve fog area. Even there is obvious progress in fog remote sensing (LEE et al. 1997; Cermak and Bendix 2007; Leipper 1994; Zhang and Bao 2008; Gao et.al. 2009), fog is still difficult to be detected by satellite under higher cloud. While recently years, lots of automatic meteorological stations are brought into operation in Qingdao or other cities. This gives us a chance to get higher resolution and more accurate fog distribution over land. Even lots of the automatic meteorological stations have no visibility records, this study still builds a method to recognize hourly fog distribution using two years of Qingdao area automatic meteorological stations data, combined with ten years' observations of sea fog/land fog. Based on this method, the temporal and horizontal distribution of sea fog landing and invading in Qingdao area are firstly obtained, and the key characteristic meteorological elements belong to the fog which deeply invades in land are also analyzed. The result shows a good performance on fog monitoring, forecasting and early warning of sea fog invading in Qingdao area.

P-059

On-ground evaluation of in-situ solar-affected temperature correction of radiosonde using dual thermistors

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Upper-air temperature is known as one of most important essential climate variables (ECVs) for weather forecasting and study of climate change. Usually radiosondes equipped with many sensors are used to monitor the upper-air environments in world wide. However the solar heating of temperature sensors has been a main reason of temperature error and thus many trials have been done to reduce or eliminate the solar heating effects.

Recently, through the measurement of relative temperature difference of dual thermistors having different emissivity installed in sensor boom, it has been proposed that this technique can correct the in-situ temperature change of radiosonde due to solar heating and/or radiation cooling. Temperature correction can be done by measurement of as-read temperatures of dual thermistors and in turn calculation of solar irradiation and then finally extraction of the true correction values. Calculation of solar irradiation mainly depends on the pre-determined calibration method performed at the ground level laboratory by varying pressure, temperature, ventilation under well controlled solar irradiance. From this ground level calibration, the correction formula is obtained and applied.

In order to prove the effectiveness of dual thermistor technique, field test system is setup on ground outside. This system is composed of two sensor booms having two thermistors having different emissivity of which one is as-received (denoted as white) and the other is coated with high emissivity carbon paste (denoted as black), a pyranometer, an ultrasonic wind anemometer, a barometer and two set of screens installed with temperature and humidity sensors in both. Temperature measured by thermometer inside the screen will act as the reference air temperature. All sensors were calibrated by KRISS, a national metrology institute of Korea, before installation. This system will be exposed to natural environment from morning to night for several months, and the measured and calculated irradiance will be compared. Eventually the solar corrected temperature will be compared with the reference temperature measured in the screen. From these tests, it is expected to verify the effectiveness of dual thermistor radiosonde (DTR) technique.

P-060

Evolution of Surface Temperature during Global Warming Hiatus Based on Observations and CMIP5 Simulations

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The rise in global surface temperature has significantly declined after 2000. It was called the global warming hiatus by many scholars. In this study, We focus on the annual and seasonal trend characteristics of observed surface temperature in different regions during the global warming hiatus and the future tendency. The evolution of the surface temperature of the global land-mean was analyzed based on Climatic Research Unit (CRU) observations. Simulations and projections were also evaluated using the Coupled Model Intercomparison Project 5 (CMIP5).

The results indicate that, in the global warming hiatus period, the trend of the global land-mean surface temperature is only 0.14℃/(10a), which is half that during 1976-1999. The trend is less than that before 2000 in nine of the 13 global land regions, and four of them show a decreasing trend. The Eurasia middle-high latitude region (40-65°N, 45-150°E) is the most interesting among all the 13 global land regions. For 1976-1999, the Eurasia middle-high latitude region shows the largest warming among all the land regions and reaches 0.50℃/(10a). After 2000, the trend significantly declines to -0.17℃/(10a), the greatest cooling trend over land, globally, contributing 49.13% of the remarkable change in global land surface temperatures before and after 2000. Furthermore, the surface temperature of the Eurasia middle-high latitude region shows an opposite change in autumn and winter after 2000; the temperature of the former rises by 0.86℃ /(10a), while the that of the latter decreases by 2.68℃ /(10a). Judging from configuration of the atmospheric circulation, in lower troposphere, the intensity of Siberian High weakens interdecadally in autumn, while enhances in winter; In upper troposphere, the geopotential height presents a "high-low-high" anomaly distribution from Western Europe to Northeast Asia, with zonal circulation strengthened and meridional circulation weakened, while in winter, the geopotential height presents a dipole pattern between polar and Lake Baikal region, with East Asian trough deepened and meridional circulation strengthened.

Based on the variation which the trend of global land-mean surface temperature showed since 1900, we defined four typical periods: warming(1911～1940), cooling(1941～1958), accelerating(1976～1999), and the hiatus period. Out of 33 models of CMIP5 historical experiments we have chosen, 4 models have familiar simulation results of global land-mean surface temperature in decadal timescales, which are bcc-csm1.1, IPSL-CM5A-MR, MRI-ESM1 and CESM1(WACCM). In CMIP5, only the simulation and projects in BCC-CSM1.1 under the RCP2.6 scenario and MRI-ESM1 under the RCP8.5 scenario reproduce the evolution of the global land-mean and Eurasia middle-high latitude surface temperature, as well as the opposite change between autumn and winter of the Eurasia middle-high latitude region, during the global warming hiatus. Besides, the spatial distribution of Eurasia middle-high latitude surface temperature which MRI-ESM1 under the RCP8.5 scenario shows is also consistent with CRU observation. The temperature projection of the BCC-CSM1.1 under the RCP2.6 scenario for the Eurasia middle-high latitude remains flat, near 1.2°C, after 2012, and jumps to 2°C after 2020. The change in the MRI-ESM1's projected temperature under the RCP8.5 scenario is close to zero before 2030; the temperature then rises remarkably, to 0.51℃/(10a), far more than any heating rate of any period since 1900.

P-061

Prediction of near-future tropical cyclone activity over the North Atlantic

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Prediction of tropical cyclone (TC) activities is essential to better prepare for and mitigate the TC-induced disasters. Although many studies have attempted to predict TC activity on various time scales including seasonal and century scales, very few focused on near-future predictions. The changes of TC activity in the next several decades are among the most imminent concerns due to their potential for huge damages in coastal regions. Thus, there has been a growing demand to explore the near-future changes in TC activity such as the location and frequency of TC genesis, intensity, and track patterns.

Here we show a decrease in seasonal TC activity over the North Atlantic (NA) for the period of 2016-2030. A track-pattern-based model has been applied in this study to predict TC genesis and occurrences over the entire NA basin. For the atmospheric and oceanic input data, three long-term simulations of the National Centers for Environmental Prediction Climate Forecast System (CFS) initialized in 1988, 1996, and 2002 are used. These three ensembles of CFS simulations predict unfavorable conditions for TC development including strengthened vertical wind shear, enhanced low-level anticyclonic flow, and cooled sea surface temperature (SST) over the tropical NA in the near future.

To understand the predicted decreases in TC activities combined with climate variabilities, we examine the changes in the NA basin-wide SST (NASST) and El Niño-Southern Oscillation (ENSO), the two dominant modes that control the NA TC activity. The positive phase of NASST is responsible for the higher basin-wide SSTs and reduced vertical wind shear over the NA. For the case of ENSO, fewer (more) TCs have occurred in the NA due to stronger (weaker) vertical wind shear and greater (weaker) atmospheric stability over the Caribbean and the tropical Atlantic basin during the El Niño (La Niña) episodes. Most of the TC changes are attributable to cooling of the NASST and more frequent El Niño episodes in the near future. However, the mechanisms behind the weakening of the NA TC activities in near-future period vary among regions: A phase shift in the NASST from positive to neutral weakens TC activities over the open ocean whereas more frequent El Niño episodes also notably suppress TC activities throughout the NA basin.

The cooling of NASST in the near-future period would be an unsuspected issue when we consider recent global warming trend induced by the anthropogenic greenhouse gas emissions. As an attempt to understand this discrepancy, we analyzed the near-future SST predictions in other Coupled Model Intercomparison Project 5 (CMIP5) models to discuss the main driver of NASST variability and ultimately of TC activity changes in the near future. When we investigate the near-future SST warming distribution for the 24 multi-model ensemble average of CMIP5 projections, not only the eastern Pacific SST warming but also the NASST warming in the near future are found. Considering the CMIP5 ensemble average represents an effect due to the anthropogenic forcing, our results suggest that natural variability, act to decrease the NASST, is more dominant than anthropogenic forcing over the NA in the near-future period.

Near-future prediction should be treated differently from long-term climate projection which is dominated by external forcing. Our study emphasizes the role of natural variability than anthropogenic forcing on the near-future climate and associated the NA TC activity changes. We hope that this study can address the scientific challenges and fairly satisfy the social needs in preparing for TC-induced disasters with long-range plans.

P-062

Effect of covariance estimation in local ensemble transform Kalman filter on short-range forecasts

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The ensemble Kalman filter (EnKF) is a widely used data assimilation method, which provides initial conditions using analysis and associated covariance that are estimated through the assimilation process. The issues that should be considered in the EnKF-based data assimilation system to provide more precise initial conditions are undersampling and the noise in covariance estimation. The undersampling caused by insufficient ensemble size leads to filter divergence by underestimating the analysis covariance in the data assimilation process, and the spurious correlation (i.e. noise) between observations and the ensembles of backgrounds reduces the accuracy of the covariance estimation. To overcome these issues, the covariance inflation and covariance localization methods have been used.

In this study, to evaluate the effect of the covariance inflation methods on short-range forecasts, several systems are constructed using a high-resolution numerical weather prediction (NWP) model with local ensemble transform Kalman filter (LETKF). The effects are statistically analyzed for the period during the one month period of July 2016. The comparisons between the constructed systems are conducted using various verification scores such as root mean square error (RMSE), spread, Brier skill score (BSS), and equitable threat score (ETS). By comparing the characteristics of initial conditions and forecast performances of the constructed systems, the system with the relaxation to prior perturbation (RTPP) method which is one of the covariance inflation methods showed best forecast performance. In contrast, the system without the covariance inflation method showed worst forecast performance. Compared to other systems, the system with the RTPP showed the best forecast performance because the RTPP mitigates the underestimation of analysis covariance in densely observed regions. The multiplicative inflation and relaxation methods are suitable to account not only for sampling error due to the limited ensemble size but also for unrepresented observation-network-dependent assimilation errors. Therefore, in the given system, the system with the RTPP well represented the errors that occurred during the data assimilation process in initial conditions, and this led to the improvement of forecast performance.

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P-063

A strong temperature dependence in precipitation associated with intense extratropical cyclones indicated by inter-hemispheric contrast of cyclones

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Extratropical cyclones, a major element of day-to-day weather in the midlatitudes, comprise fine-scale cold and warm fronts, and imbedded fine-scale storms, as part of an organized cloud-precipitation system. They are sometimes associated with intense precipitation that can lead to flash floods. In the past, it has been difficult for both climate models and satellite observations to capture the statistical features of the fine-scale precipitation systems embedded within cyclones. Here we use a state-of-art global high-resolution model, NICAM (non-hydrostatic icosahedral atmospheric model), and a new observational dataset from GPM (global precipitation measurement) satellite to study the climatology of the mean precipitation from intense cyclones and its expected changes with warming. The present and future climate simulations were performed for 25 years with a horizontal mesh size of 14 km. Comparisons to observations and reanalysis suggest that the model realistically represents the observed averaged spatial pattern of the precipitation, mean sea level pressure, low-level wind speed and cloud radiative effect around intense cyclones in the present climate. Simulations show that, for the most intense cyclones, the precipitation depends on surface air temperature following the Clausius-Clapeyron scaling of 7% K-1, which holds for any combinations of hemispheres and climates. For all the cyclones, this scaling does not hold between the hemispheres. Our findings indicate that hemispheric contrast in the present day climatology of intense cyclones provide a compelling indication of how they will change with future warming.

P-064

Synoptic-scale waves in sheared background flow over the western North Pacific

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Tropical depression (TD)-type wave is the dominant mode of synoptic-scale fluctuations over the western North Pacific. More than 50% of tropical cyclongenesis are directly induced by these TD-type waves. However, the activity, variation and mechanism of these TD-type waves are still not completely clear. In this report, through statistical, diagnostic and comparative study, the critical role of the vertical shear of zonal ambient flow is investigated and discussed.

By applying spatio-temporal filters to the observed OLR data and the NCEP-DOE AMIP II reanalysis data for 1979-2013, this study reveals the characteristics and energetics of convectively coupled TD-type waves under the effects of different circulation patterns in association with vertical wind shear. Results exhibit that different ambient sheared flows significantly affect the vertical structure of westward-propagating TD-type waves, with a lower-tropospheric mode in an easterly sheared background and an upper-tropospheric mode in a westerly sheared background. Energetic diagnoses demonstrate that when the disturbance is trapped in the lower (upper) level by easterly (westerly) shear, the horizontal mean flow in the lower (upper) level favors wave growth by converting energy from the shear of the zonal mean flow (from the convergence of the meridional mean flow). During the penetration of a westward-propagating synoptic-scale disturbance from a westerly sheared flow into an easterly sheared flow, the upper-level disturbance decays, and the lower-level disturbance intensifies. Meanwhile, the upper-level kinetic energy is transferred downward, but the effect induces the wave growth only confined to the mid-levels. Consequently, the low-level growth of the westward-propagating upper-level synoptic-scale disturbance is mainly attributed to the barotropic conversion of horizontal mean flow in the lower troposphere.

Moreover, using CFSR reanalysis data, JTWC best track, TRMM precipitation rate data, two long-lasting synoptic-scale wavetrains are also selected and compared for investigating the critical roles of zonal vertical wind shear and corresponding large-scale circulation on these synoptic-scale disturbances. Analysis results show the long-lasting wave train during 2004 mainly occurs over the region from 130°E to 160°E, featuring enhanced perturbations in association with enhanced tropical cyclone activity. In contrary, during 2006, the wave train propagates over the region from 120°E to 150°E with more poleward direction. The essential differences between these two synoptic-scale wavetrains are that the primary propagation occurs from middle to lower troposphere with a nearly equivalent barotropic structure during 2004, but at upper-troposphere with significant westward tilt during 2006 in specific stages. This is caused by the different signs of the environmental vertical shear of the zonal flows during different years. In 2004, affected by weak easterly shear, the synoptic-scale waves are confined at lower troposphere. However, in 2006, the effect of weak westerly shear is the key factor accounting for trapping disturbances at upper troposphere. This comparative study demonstrates that these tropical synoptic-scale disturbances are sensitive to the sign of background vertical wind shear.

These results will improve our understanding of the activities of synoptic disturbances, and has an application potential to be used in the prediction of tropical disturbances and typhoons over the western North Pacific.

P-065

Statistics of Gust Fronts Character and Condition Analysis of Convective Storm Which are Triggered by Gust Fronts in Beijing Area

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Reflectivity and radial velocity data of CINRAD-SA Doppler Radar and subjective identification method are used in this article to make statistics of the gust fronts in warm season (May to September) in 2006-2015, and there are 410 processors. The gust fronts occur high frequency in July and August, which occupied about 73% of the total number, June ranks second which about 16%, and May and September are the least months. The results show that the reflectivity of thunderstorm which produced gust fronts are between 40-71dBz, and about 7% thunderstorms' reflectivity of radar are between 40-50dBz, 56% are between 50-60dBz, and 37% are above 60dBz. There were 252 processors triggered convection in 410 processors, which occupied 62% in total.

Sounding data, automatic station data, the wind profiles, Microwave radiometer and the Variational Doppler Radar Analysis System (VDRAS) are used to analyze five processors in which gust fronts triggered convective storms and other five processors not triggered convective storms. The results showed that, (1) if there are two or more than two gust fronts join, there will trigger convective storms. (2) If the gust fronts pass the instability area, the convective storms would be triggered easily. (3) If the gust fronts moving directions are consistent with the environment wind, the convective storm would be triggered easily.

P-066

Evolution of midtropospheric vortex and convection in the pregenesis stage of Super Typhoon Megi (2010)

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Based on a successful cloud-resolving simulation, this study examines the evolution of midtropospheric mesoscale cyclonic vortex (MCV) and convection during the formation of Typhoon Megi (2010). In the first episode of deep convection in the pregenesis stage of Megi, substantial downdrafts initially fueled by evaporative cooling and then forced by strong near-surface divergence induces the formation and intensification of a MCV. As the MCV intensifies, onion-shape sounding as well as near-surface anticyclonic circulation accompanying by low sea-level pressure developed below the MCV. The continuing geostrophic adjustment of the wind and pressure fields and the wind surge from the environment caused shallow convection beneath the MCV, which increases the low-level relative humidity and near-surface vorticity. In the following congestus convection phase, the mid-to-upper-level potential instability increased under the joint effect of convection and mid-to-upper-level dry air intrusion, which together with the strengthened low-level vorticity and jets caused the second episode of deep convection leading to Megi formation. The near-periodicity of deep convection before Megi formation was found to be related to the radiation cycle and geostrophic adjustment induced by deep convection.

The MCV weakened considerably in the shallow and conguestus convection phases while experienced fluctuating growth during the intermittent deep convection phase. Since the convection mainly occurs at the MCV's skirt, the role of MCV in Megi formation may not be in protecting the pre-Megi from vertical wind shear and dry air intrusion but in triggering new convection via the interaction of the near-surface divergent flows related to MCV intensification and the surges from the environment.

P-067

Regional Climate Projections with Dynamical Downscaling over India

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Climate change study in India needs thrust on its regional aspects mostly because of its varied climate types. Since global model outputs are available from several well recognized international modeling communities, it may be worth using those model outputs to run regional models over India at higher resolutions and thus dynamically downscale the global model outputs. These regional model outputs in turn may be utilised to generate some important meteorological parameters such as temperature, rainfall, wind and humidity at required resolutions for their subsequent use in the study of weather extremes and human health.

In this study, some important climate change signals and their future projections have been examined over four Indian cities using the Regional Climate Model (RegCM) of the Abdus Salam International Centre for Theoretical Physics (ICTP). These simulations were done under the Coordinated Regional Downscaling Experiments (CORDEX) programme over the South Asia domain. Here, the state-of-the-art version 4 of RegCM has been integrated from 1970 to 2099 at 50 km horizontal resolution driven by the global model GFDL-ESM2M. The simulated mean summer monsoon circulation and associated rainfall by RegCM4 are validated against the observed values in the reference period 1975 to 2004 based on GPCP and IMD data sets. Regional model results are also compared with those of the global model GFDL which forces RegCM4. Future projections are categorized as near-future (2010-2039), mid-future (2040-2069) and far-future (2070-2099). Comparison of projected seasonal (June-Sept) mean rainfall from the different time slices indicate gradual increase in the intensity of changes over some of the regions under both the scenarios RCP4.5 and 8.5.

This talk will focus on the changes in temperature and rainfall extremes at Delhi, Mumbai, Chennai and Guwahati and in the respective meteorological subdivisions and homogeneous zones. Results show differences in the characteristics of temperature and rainfall changes over different regions of India. However, the most important results over India at large include increase in the frequencies of occurrence of heavy rainfall incidents of shorter durations and warmer nights. This study further indicates that it is possible to use downscaling techniques so as to generate robust climate change signals at different places in India which can be used for the benefit of the people. Results project robust signals in the increase in maximum and minimum temperatures at almost all cities under consideration. There is also robust signal of decrease in the occurrence of cold nights.

P-068

Atmosphere-ocean-wave interaction during the passage of a tropical cyclone in the north Indian ocean

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A regional coupled atmosphere-ocean model used to study the interaction of atmosphere-ocean-wave during the extreme weather condition associated with the passage of a tropical cyclone in the Bay of Bengal (BoB), a semi-enclosed basin in the north Indian ocean. The atmospheric model Weather Research and Forecasting (WRF-ARW) exchanges variables through the model coupling toolkit (MCT), as part of COAWST modelling system, with the Regional Ocean Modelling System (ROMS). The ocean spectral wave model Simulating WAves Nearshore (SWAN) supplies the ocean wave parameters such as wave height, wave energy dissipation, propagation direction, and wave-length to the coupled model. Impact of cyclonic wind stress was clearly seen in the simulated thermohaline structure of upper ocean in the northwestern BoB. As a result of cyclone-induced upwelling, the sea surface temperature (SST) reduced by 2°C with marginal increase in surface salinity. Oceanic surface waves impose surface roughness to the lowest vertical level in the WRF model and, therefore, affect the momentum exchange between ocean and atmosphere. Impact of ocean wave-current interaction were more pronounced in the coastal regions close to the landfall location of the tropical cyclone. Signature of ocean upwelling were noticed off the east coast of India in both observations and numerical simulations. Further, the mechanism of mixing in the ocean were explored. Analysis of baroclinic and barotropic current components showed stronger subsurface (10-15 m depth) energy with baroclinic currents inductive of mixing at the subsurface levels. Model results are discussed to highlight the interaction of oceanic waves with the surface atmospheric variables in the coupled modelling framework.

P-069

The role of wave trains in the intensification of mid-latitude wintertime waviness

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Changes in the amplitude of meanders affecting the atmospheric flow in the Northern Hemisphere have recently garnered a lot of attention. Despite the recent development of many indices to characterize the waviness, we still lack a good understanding of how they are related to weather events. In this study, episodes of intensified mid-latitude waviness are identified using a measure of finite amplitude local wave activity applied to the 500-hPa geopotential height field from reanalysis data. Wave intensification events are found to result from the constructive interference between transient eddies and the stationary waves. When transient eddies align with stationary waves of the same polarity, cyclonic wave activity is intensified over Northeastern Canada and East Asia and anticyclonic wave activity is intensified over Alaska and Europe. The events of enhanced mid-latitude waviness are accompanied with marked changes to the occurrence of temperature extremes, supporting the need to better understand how waviness may change in the future. The wave intensification events are further shown to be associated with quasi-stationary Rossby wave trains whose origin, whether from the mid-latitudes, subtropics or Arctic, depends on the geographical location of the events.

P-070

Intense tropical cyclones in 50-member ensemble simulations for 1997 and 2015 using a global nonhydrostatic model

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El Niño influences tropical cyclone (TC) activity in the western North Pacific. Camargo and Sobel (2005) showed that TC lifetime and the number of intense TCs increase during El Niño. In 2015, strong El Niño event was developed. Wang and Chan (2002) showed that intense TCs tend to be formed over the southeastern part of the western North Pacific during El Niño. According to the Regional Specialized Meteorological Center Tokyo best-track data, in the western North Pacific, 10 intense TCs were formed between June and October in 2015, which was the largest number since 1971. In this study, intense TC is defined as TC whose minimum central pressure reached less than 945 hPa.

To evaluate the influence of El Niño on the number of intense TCs, we conducted 50-member ensemble simulations targeting the summers (June-October) of 2015 and 1997 known as development of extreme El Niño event, using a global nonhydrostatic model called NICAM (Satoh et al. 2014) with a horizontal grid interval of 14 km. Clouds were explicitly calculated using a single-moment bulk microphysics scheme without cumulus convection scheme. The sea surface temperature was nudged toward the OISST data (Reynolds et al. 2002) using a slab ocean model.

In the ensemble simulation of 1997, the ensemble-mean of number of intense TCs is 7.0 which is higher than the model's climatology (5.8) which is derived from an AMIP-type 30-year simulation (Kodama et al. 2015). Moreover, intense TCs tend to be formed over the southeastern part of the western North Pacific and have longer lifetime. Those results indicate that the model response of TC activity to El Niño in 1997 agree with observed response (Wang and Chan 2002; Camargo and Sobel 2005). On the other hand, in the ensemble simulation of 2015, ensemble mean of the number of intense TCs is almost equal to the model's climatology. Whereas intense TCs simulated in the members with 7 or more intense TCs tend to be formed over the southeastern part of the western North Pacific and have longer lifetime, this feature are not obvious in the other members. These results indicate that the number of intense TCs is not determined only by development of El Nino-type sea surface temperature pattern but is influenced by the internal variation of the atmosphere induced by differences in the sea surface temperature distribution between 1997 and 2015.

P-071

Prediction analysis of physical and dynamical processes of liquid water content over Indonesia

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The existence of liquid water content in the tropical atmosphere is very interesting to study because it shows various physical and dynamic processes in the atmosphere. The atmosphere above Indonesia is very unique and complex that plays an important role in the weather and the global season. This research attempts to analyze the physical and dynamic processes due to the presence of liquid water in the atmosphere. Predicted moisture content is done using a barotropic model. The data used are geopotential height and mixing ratio at standard pressure. The study area includes 12^{o}N to 12^{o}S and 90^{o}E to 150^{o}E. Assuming that there is no liquid water above the height of 400 mb, the following results are obtained. There are convergence areas in some parts of Indonesia that are visible from the location of liquid water content in the area. Prediction test results at an altitude of 850 to 400 mb with a spacing of 50 mb from 1 to 8 August 2017 show that the location of convergence of clouds has shifted in the direction of the streamline. Generally the more upward the amount of liquid water in the atmosphere decreases and the more the day increases. During the prediction periods many massive vertical clouds existed over the mainland islands of Borneo, Papua, and Sumatra Indonesia as well as the northern part of the study area. This shows the magnitude of the convergence and convection processes occurring in these areas.

Key words: prediction, liquid water, barotropic, tropical atmosphere

P-072

Early detection of tropical cyclones using communication, ocean, and meteorological satellite infrared images and machine learning approaches

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A tropical cyclone (TC) is one of the large scale atmospheric events in the world. Plenty of rains and winds are accompanied with TCs, which causes enormous socioeconomic losses when TCs approach where people live. TCs are formed in equatorial regions, and move to upper latitudes. Therefore, mid latitude countries have tried to predict their paths and intensities using satellite remote sensing data and numerical forecast models to appropriately prepare against TCs. Twenty to thirty of TCs are annually developed from tropical disturbance, while thousands of disturbances are generated and decayed in the ocean. Therefore, the accurate and early detection of developing disturbance is crucial to appropriately respond to potential disasters. Although numerical forecast models are good at predicting various atmospheric events, they do not work well for early detecting TCs because there are not well defined mechanisms for TC formation. A recent study suggested a deviation angle variation (DAV) technique, which is an early TC detection method, based on the quantification of cloud symmetry using cloud images from geostationary satellite data. Although the DAV technique has a strength in frequent monitoring with a 15-20 min interval, the cloud-based index resulted in a high false alarm. Park et al. (2016) suggested a method to determine developing disturbances using wind pattern and intensity, and spatial distribution of wind patches from polar orbiting Windsat satellite data,. The method adopted decision trees to generate several rules to determine developing disturbances. Less frequent data collection from the polar orbiting satellite sensor might be a limiting factor in monitoring tropical disturbances though.

In this study, we suggested an early TC detection approach using geostationary satellite data and machine learning techniques based on various cloud patterns and its spatial distribution. Communication, Ocean and Meteorological Satellite (COMS) Meteorological Imager (MI) data collected between April 2011 and December 2015 over the Northeast Pacific region were used in this study. The developing and non-developing disturbance tracks were provided from the collaborating joint typhoon warning center (JTWC) best track with national centers for environmental prediction final (NCEP FNL) data. Derived disturbance tracks were downscaled to 1 hour and 0.1º, using a DAV method suggested by Pineros et al. (2005). Cloud patterns were quantified using landscape indices (e.g. Shannon's evenness index, Simpson's diversity index) within the 700km radius of the disturbance center from each infrared channel (e.g. Shortwave infrared at 3.75 μ m; water vapor at 6.75 μm; infrared1 at 10.8 μm; infrared2 at 12.0 μm). Extracted cloud indices were employed to classify developing and non-developing disturbances using decision trees and random forest models. Data from 2011 to 2014 were used to train the machine learning models, and 2015 data were used to validate the models. Results showed that all 9 developing disturbance cases in 2015 were well detected from the random forest model, but 18 cases of the 38 non-developing disturbances were falsely detected. The random forest machine learning approach yielded a high detection rate (100%) but a relatively high false alarm (~47%), which requires additional refining of the model focusing on input feature selection and parameter optimization.

P-073

Evaluation of Forecast Performance of Asian Summer Monsoon Low-Level Wind using TIGGE Dataset

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The forecast performances of the East Asia summer monsoon (EASM) and South Asia summer monsoon (SASM) by six THORPEX Interactive Grand Global Ensemble (TIGGE) centers in the summers of 2008-2013 were evaluated to reflect the current predictability of state-of-the-art numerical weather prediction. The results show that the EASM is overestimated by all TIGGE centers except the Canadian Meteorological Center (CMC). The SASM is also overestimated by the European Center for Medium-Range Weather Forecasts (ECMWF), China Meteorological Administration (CMA), and CMC, but is under-predicted by the Japan Meteorological Agency (JMA). Additionally, the SASM is overestimated for early lead times and underestimated for longer lead times by the National Centers for Environmental Prediction (NCEP) and United Kingdom Meteorological Office (UKMO). Further analysis suggests that such biases are likely associated with those in related land-sea thermal contrasts. The EASM surge is overestimated by the NCEP and CMA and mainly underestimated by the others. The bias predictabilities for the SASM surge are similar to those of the SASM. The peaks of the SASM and EASM, including their surges, are mainly underestimated, whereas the valleys are mostly overestimated. Overall, the ECMWF and UKMO have the highest forecast skill in predicting the SASM and EASM and both have respective advantages. The TIGGE centers generally show higher skill in predicting the SASM than the EASM, and their skill in forecasting the SASM and EASM is superior to that for their respective surges. Moreover, bias-correction forecast skills show improvement with higher correlation coefficients in raw forecast verification.

P-074

On spatiotemporal characteristics of sea fog occurrence over the Northern Atlantic from 1909 to 2008

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In this paper, the International Comprehensive Ocean and Atmosphere Data Set (ICOADS) is utilized to investigate the horizontal distribution of sea fog occurrence frequency over the Northern Atlantic as well as the meteorological and oceanic conditions for sea fog formation. Sea fog over the Northern Atlantic mainly occurs over middle and high latitudes. Sea fog occurrence frequency over the western region of the Northern Atlantic is higher than that over the eastern region. The season for sea fog occurrence over the Northern Atlantic is generally from April to August. When sea fogs occur, the prevailing wind direction in the study area is from southerly to southwesterly and the favorable wind speed is around 8 m s-1. It is most favorable for the formation of sea fogs when sea surface temperature (SST) is 5°C to 15°C. When SST is higher than 25°C, it is difficult for the air to get saturated, and there is almost no report of sea fog. When sea fogs form, the difference between sea surface temperature and air temperature is mainly -1 to 3°C, and the difference of 0°C to 2°C is the most favorable conditions for fog formation. There are two types of sea fogs prevailing in this region: advection cooling fog and advection evaporating fog.

P-075

A Fog Event off the Coast of the Hangzhou Bay in China during Meiyu Period

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A dense fog with the visibility less than 100 m over 6 hours occurred around the Hangzhou Bay off the coast of the western part of the East China Sea on 24-25 June 2013 during Meiyu period. This study focuses on the physical mechanism involved in the fog process by using in-situ observations and model. The analysis indicates that a coastal front-like system played an essential role in the fog episode, while a weak low-pressure wedge associated with the Meiyu front and the diurnal variation in temperature provided background conditions. Induced by the meso-scale coastal front-like system, a secondary circulation formed in the lower levels of the atmospheric boundary layer (ABL). The southeasterly wind and subsiding motion associated with the secondary circulation contributed to the moisture supply and the lowering of the boundary layer, favoring fog formation and maintenance. The fog maintained until the weakening of the coastal front-like system, when the downward flow was replaced by upward motion controlled by the approaching of a low-pressure center. These results are helpful for improving coastal fog forecast in Meiyu period and for our understanding of mechanisms involved in coastal fog processes.

P-076

Observational study on the pre-tropical cyclone squall line of 8 august 2007 over the coast of South China

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A squall line in front of tropical cyclone occurred in the west of the Pearl River Delta to Zhanjiang on Aug 8th, 2007 when the tropical storm Pabuk approached South China. The development, structure and environmental conditions for this squall line were investigated in this study, with particular attention paid to the possible connection of this squall line with Pabuk. The observational data employed in this study are from soundings, Doppler weather radars and wind profile radars. The following six major conclusions are drawn by our observational analyses. (1) This squall line developed gradually from individual convective cells, and land breeze may be responsible for the onset of the squall line. (2) The path and intensity of the squall line were modulated by the environmental conditions. The squall line propagated along the coastline, and it was stronger on the land-side of the coastline compared with the surrounding in-land regions and oceanic regions. (3) The typical characteristics of tropical squall lines were seen in this squall line, including the cold-pool intensity, vertical structure and the wake flow stratiform precipitation at its developing and mature phases. (4) The environmental conditions of this squall line resemble those of tropical squall lines in terms of deep moist air and low convection condensation level. They also resemble mid-latitude squall lines in terms of the convective instable energy and vertical wind shear in the lower troposphere. (5) Two roles were played by the strong wind around Pabuk. On the one hand, it made the atmosphere more unstable via suppressed shallow convection and increased solar radiation. On the other hand, it enhanced the land-sea thermal contrast and therefore strengthened the sea breeze and the resultant water vapor transport. The sinking temperature inversion prevented the occurrence of low-layer weak convection and accumulated convection instability energy for the development of the strong convection.

Key words: squall line; tropical cyclone; land breeze; environmental conditions

P-077

Factors Determining the Asymmetry of ENSO

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A fundamental aspect of the observed El Nino-Southern Oscillation Phenomenon (ENSO) is the positive asymmetry between its two phases-the magnitude of El Nino tends to be stronger than the magnitude of La Nino in either their averages or their extremes. Factors involved in determining this positive asymmetry, however, are not well understood. This poor understanding is reflected in the diversity of this positive asymmetry simulated by our state-of-the-art CMIP5 models. The asymmetry simulated by these models ranges from negative asymmetry to positive asymmetry, with most models underestimating the positive asymmetry as seen in observations.

Here we employ a nonlinear, analytical, box model for the coupled tropical Pacific ocean-atmosphere to investigate the role of a multitude of factors in determining ENSO asymmetry. These factors include the intensity of radiative forcing, the strength of the dynamical coupling between the atmosphere and ocean, the thermal damping rate from the atmosphere, the adjustment time-scale for the tropical upper ocean (or upper ocean memory), and the relative strength of the equatorial zonal advection versus the total equatorial upper welling. The model has been previously shown to capture major aspects of ENSO including its positive asymmetry.

We find that all aforementioned factors play a role determining the ENSO asymmetry. The relationship between these factors and the ENSO asymmetry is complex, however. With the exception of the memory of the upper ocean which has a largely linear impact on the ENSO asymmetry (the longer the memory, the stronger the positive asymmetry), the effects of the intensity of radiative heating, the dynamical coupling strength, the thermal damping rate from the atmosphere, and the strength of the zonal advection on the ENSO asymmetry are very nonlinear. Depending on the regime the system is in, an increase/decrease in these parameters can either increase/decrease the ENSO asymmetry. It is also found that ENSO in the model can have substantially negative asymmetry, substantially positive asymmetry, or no asymmetry. Which of three regimes the system finds itself in depends on the values of the aforementioned parameters. The results also show that the relationship between the amplitude of ENSO and the asymmetry of ENSO is nonlinear-whether an increase in amplitude of ENSO corresponds to an increase in the asymmetry depends on the regime the system is in.

These results reveal that ENSO asymmetry is influenced by a multitude of physical processes. Diversity of ENSO asymmetry is also found in this simple model, which shall help to understand the diversity of ENSO asymmetry in CMIP5 models. The sensitivity studies from this model also reveal a few situations under which the asymmetry tend to be negative or very weak positively, offering paths to take to understand the general underestimate of the positive asymmetry of ENSO by our state-of-the- art models.

P-078

Verification of HNS atmospheric dispersion monitoring system exposed by a cargo ship accident at the sea

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As hazardous and noxious substances(HNS) shipments are increasing near Korean peninsula, which caused the risk of HNS accidents has emerged as a challenging issue in recent years. The meteorological information on maritime accident site is needed to resolve the accident, and the diffusion of HNS that are harmful to the human body should be also predicted.

We have attempted to introduce a HNS atmospheric dispersion monitoring system using WRF-chem model focusing on sensitivity test. Since the system starts every six hours, the eight products at the same time were verified using buoy observation data during winter and typhoon season in 2015 (from mid-January to February and from July to September). Then the statistics were compared to find which period shows the best accuracy of the eight products. The statistical methods for verification were used RMSE and correlation coefficient for wind speed, sea level pressure, and temperature. For wind direction, the forecast skill score was computed.

For the eight experiments correlation coefficient/RMSE values were slightly decreased/increased as composed lead time fade from model initial time at the buoy sites. Correlation coefficient for the forecast evaluation showed more than about 0.6 for sea level pressure, temperature and wind speed for the two periods. The value of RMSE were less than about 2.2 hPa for sea level pressure; 1.5℃ for temperature; and 2.6 m/s for wind speed. For wind direction skill score were more than about 60%.

The developed HNS atmospheric dispersion monitoring system can be used to alert risk of HNS exposure accidents caused by severe weather over the sea around the Korean Peninsula. Also the system might be essential to response maritime accident especially off the shore without observation data.

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P-079

Heavy precipitation events during the SW and NW monsoon seasons in Sri Lanka: A Sensitivity Study of WRF Model Physics Parameterization

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This study focused on simulating heavy precipitation events observed over Sri Lanka on 16th May 2016 and 23rd January, 2017 using the Weather Research and Forecasting (WRF) model. These two events correspond to the south-west monsoon and north-east monsoon seasons in Sri Lanka, respectively. In the south-west monsoon event (May), a low pressure system originated from the southeast of Sri Lanka and the south-west monsoon onset result in heavy precipitation over northern and northwestern parts of the country. The north-east monsoon event (January) was associated with monsoon flow and with easterly disturbances during the season resulted in heavy precipitation over eastern Sri Lanka. The WRF model is extensively used for both research and operational weather forecasting applications. Hence, this study aims to investigate the sensitivity of the WRF to heavy precipitation events by examining a series of mesoscale simulations of various parameterization schemes such as four different microphysics (MP) schemes (WSM5, WSM6, WDM5 and WDM6) and eight cumulus (CU) parametrizations (Kain-Fritsch, Betts-Miller-Janjic, Grell-Freitas, Old Simplied Arakawa-Schubert, Grell-3, Tiedtke, Multi-scale KF, New Simplied Arakawa-Schubert and New Tiedtke), in order to reproduce the precipitation and also operationally to predict future heavy rainfall events during the south-west and north-east monsoon seasons.

The model domains consists of an outer domain with 9km grid resolution and an inner domain with 3km grid resolution. For geographical input field, MODIS 2 arc minutes and 30 arc seconds data are used for outer and inner domains respectively. The model was integrated for 51 hours with output fields at 0000UTC produced by the Global Forecasting Model (GFS) with 0.25 degree grid resolution operated by National Centers for Environmental Prediction (NCEP). Initial and boundary conditions for outer domain are provided by the GFS model and initial and boundary conditions for inner domain by output of the outer domain. The target period for testing is 24 hours and the model is initialized 27 hours in advance to the forecast period. The same physical parameters are used for both outer and inner domains with one way nesting option. In addition, explicit cumulus parameterization is also used for inner domain. Model output fields are compared with available daily rainfall data from rainfall stations, 3-hour synoptic observation, and Radiosonde observation data from weather stations operated by Department of Meteorology, Sri Lanka. Statistical model evolution methods such as probability of detection, frequency bias index, threats score and root squared error for different precipitation thresholds between 0.1 mm to 200 mm are used to evaluate model results against surface and upper air observations.
The results indicate that there was a large variation in the precipitation estimated by the model using various model physics schemes while several corresponding precipitation simulations were reproduced in its spatial distribution aligning with the rainfall station data, although the amount was not estimated accurately. Further, this study indicates that the selecting single momentum 5-class, single momentum 6-class, double momentum 5-class, or double momentum 6-class microphysics with cumulus schemas had significant impacts on model simulations as well as with explicit cumulus parameterization. Moreover, the WRF model was able to capture the rainfall patterns of this event over Sri Lanka, suggesting the model has potential for operational use in numerical weather prediction in Sri Lanka.

Key words: Heavy precipitation, SW monsoon, NW monsoon, WRF Model, Sri Lanka

P-080

Evaluation of different physical parameterization schemes of the WRF model for the extreme rainfall events during 14-15 August, 2014 in Nepal

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Extreme rainfall is one of the most frequent and widespread severe weather hazards to Nepal during the monsoon season, which is the four-month period that receives roughly 80 percent of the annual rainfall. In Nepal, floods and landslides triggered by extreme rainfall are the most disastrous hydro-meteorological disaster responsible for variety of socio-economic impacts including damages of infrastructures, injuries and death. In recent years, a larger fraction of precipitation has come in the form of intense single-day events, which are considered as an indicator of climate change. The rainfall extremes show an increasing trend in terms of both the frequency and intensity over most land areas in Nepal, and this is consistent with the climate change scenario having a warming trend and observed increases of atmospheric water vapor. Due to the complex topography of Nepal, each year a number of widespread erratic and torrential rainfall events trigger floods wreaking havoc in the southern plain. The Meteorological Forecasting Division (MFD), Department of Hydrology and Meteorology (DHM), Nepal has been using the Weather Research and Forecasting (WRF) model to produce its operational weather forecasts and issue to general public for past few years. Despite some over-estimation in rainfall amounts, the forecasting skills of forecasters in the MFD has improved dramatically after the use of the model. This study is aimed at further improvement of the forecasting skills by deriving better combination of physical parameterization schemes to resolve extreme rainfall events.

In the mid-August, 2014, Nepal had been under the influence of a widespread extreme rainfall event as a result of shifting of monsoon trough towards the Himalaya foothills. Out of 360 stations, 60 and 87 stations recorded 100 mm or more rainfall on the 14th and 15th of August, respectively. While the highest amounts of daily rainfall across the nation were 300.9 mm and 442.3 mm on the 14th and 15th of August, respectively, with 5 stations recording 400 mm or more rainfall on the 15th of August. During this episode of extreme rainfall, heavy downpours were observed at the Terai and Siwalik regions of Central, Western, and Mid-Western Nepal. The catastrophe in the form of massive floods and several landslides caused major devastation in the 18 districts leading to a death toll of over 50 persons. In this study, this period is being simulated by the WRF model version 3.8.1 with the double-nested domains of 12 and 4 km horizontal resolution. Sensitivity experiments are being conducted with the WRF model to test the impact of microphysical (MP), cumulus (CP), and planetary boundary layer (PBL) parameterization schemes in capturing the extreme rainfall event. Altogether 18 simulations using combinations of three MPs - (Thompson Scheme, Lin and WSM6), three CPs - (Kain-Fritsch, Betts-Miller-Janjic and Grell-Devenyi), and two PBLs - (Yonsei University scheme and Mellor-Yamada-Janjic scheme) will be compared to a control run using the same parameterizations as being used in the operational weather forecasting in the MFD, Nepal. The model is being run for 75 h using the initial data at 0000 UTC of the 12th of August 2014 using the NCEP GFS ANL data as the initial and boundary conditions. The model simulated rainfalls will be tested against the observed point rainfall data of the 360 rain-gauge stations of Nepal in terms of Probability of Detection, False Alarm Ratio, BIAS, and Equitable Threat scores for different rainfall intensity thresholds of 25, 50, 100, 150 and 200 mm/day.

On the basis of few simulations, the WRF model is found to be able to capture the pattern of spatial distribution of the rainfall episode, but there were some deviations between the simulated and the observed data such as overestimation and slight position shift towards the east. After the completion of all the model runs, forecast verification indices will be evaluated to determine better combinations of parameterization schemes in order to assist the operational forecasting of similar extreme rainfall events in future in Nepal.

Key words: WRF model, Extreme rainfall, Monsoon, Nepal

P-081

Large-Scale Atmospheric Teleconnection Patterns Associated with the Major heat waves in Korea: The Cases of 1994, 2013 and 2016

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The heat wave is one of natural disaster in Korea which accompanies loss of human life. In 1994, there are over 3,000 of excess death due to heat wave, which is the most tragic disaster to damage human life in Korea. However, the mechanisms for onset and persistent of heat wave is too complex to understand, so it is hard to forecast heat wave events.

The large-scale atmospheric teleconnection patterns such as PJ pattern, CGT pattern and SCAND pattern are known as one of important factor to outbreak heat wave in Korea. These large-scale teleconnection pattern shows near stationary with the strong blocking events.

In this study, we try to diagnose the extreme heat wave case of Korea in 1994, 2013 and 2016. Each extreme heat wave year records 20.4, 16.6 and 21.3 days of hot days which are the highest day since 1973. We also perform intense analysis to examine the mechanisms for onset and decay of heat wave in case study.

P-082

Increased Frequency of Strong Wind in Hokkaido Region of Japan in Winter and Its Associated Explosive Cyclone Activity

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This study examined the activity of explosive cyclones in the vicinity of Japan, especially the cyclones passed the southern coast of Japan (hereafter SCJ cyclones) in winter from 1979/80 to 2016/17 by mainly using the Japanese 55-year reanalysis data. Furthermore, the rapid development process of the SCJ cyclones related to the difference in track was also investigated. The local observation data revealed a recent increase of strong wind in Hokkaido region. The reanalysis data exhibited that the enhancement of cyclone activity in the east of Hokkaido region, which is evaluated by the local deepening rate, is responsible for the increase in local extreme events. It is found that the recent increase in such extreme events mainly arises from the increased frequency of the SCJ cyclones that migrate northward and approach Hokkaido region.

This study classified the SCJ cyclones into two primary types: northward (91 cases) and eastward (142 cases) migrating cyclones, and we performed composite analyses based on the time (day 0) when the cyclones reached their maximum deepening rate. At the northward-migrating type of the SCJ cyclones (hereafter N-type), quasi-stationary Rossby wave trains prevailed along the subpolar and subtropical jets over the Eurasian Continent on day -2. Due to the downstream energy propagation, a pair of the upper-level trough and ridge appeared over Japan on day -1 and the ridge of the N-type cyclone is already stronger than that of the eastward-migrating type (hereafter E-type) cyclone. On day 0, the barotropic ridge further developed to the east of the cyclone and, as a consequence, the enhanced ridge tends to block the eastward movement of the N-type cyclone. By analysis the Rossby wave source, we find that the upper-level divergence due to the N-type cyclone triggered the downstream Rossby wave propagation, thereby contributing to the further reinforcement of the ridge. In contrast, the ridge at the E-type cyclone is weak because relatively weak upper-level divergence associated with the E-type cyclone cannot easily trigger the quasi-stationary Rossby waves.

Another finding is that the N-type cyclone intensity is strong compared to the E-type cyclone and rapidly reached the lowest central pressure. Possible reasons are given as follows: The upper-level positive potential vorticity anomalies strengthened the N-type cyclone through vertical coupling between the upper-level and surface systems. The intensified ridge to the east of the cyclone facilitates acceleration of the moisture supply from lower latitude through enhancement of the east-west pressure gradient, eventually leading to increased latent heating within the cyclone system.

In order to investigate the reason why the N-type SCJ cyclones increased recently, this study classified the occurrence period of the N-type cyclone into two periods: past (1979/80-1997/98) and recent (1998/99-2016/17), and we performed similar composite analyses for each period. In the recent period, a strong upper-level anticyclonic circulation anomaly appeared over the southern China and the northwestern part of Siberia along the two wave guides on day -2. As for the long-term tendency of the climatological mean fields, the anticyclonic circulation anomalies tend to be evident in these areas, which might be affected by the warming in the tropical ocean and the reduction of sea ice in the Barents Sea. However, further analysis and sensitivity experiments using numerical models are necessary to address this issue.

P-083

Impact of Horizontal Resolution on Seasonal Precipitation Simulation over Korean Peninsular using Two-way Nesting Method

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The most common technique to produce the detailed climate for selected regions is using Regional Climate Models (RCMs). A regional model is initialized by global model output and forced at its lateral boundaries. A number of researchers have been shown that there are limitations when applying RCMs such as the necessity of additional interpolation, inconsistency, and getting different results for each location and size of the subdomain. However, by using two-way nesting method, these problems can be averted. Therefore, in this study, summer monsoon prediction over Korean peninsula with a horizontal resolution of 40-km for the global domain, and 10-km for the nested domain using two-way nesting method will be simulated and the impact of horizontal resolution will be shown by comparing their scores. The model used for this study is ICOsahedral Non-hydrostatic (ICON) model which uses non-hydrostatic dynamical core on an icosahedral-triangular grid. It represents the globe on an icosahedral sphere so that the globe can be divided into the same size of triangles and each triangle can include the equivalent amount of energy. ICON model support two-way nesting with capability for multiple nests per nesting levels in order to replace extra process for downscaling and full hybrid MPI and OpenMP parallelization. The global domain is set with horizontal resolution of 40-km. Two pre-set child domains are set for Asia and Korea region with a horizontal resolution of 20-km and 10-km for each child domain. All domains have 90 levels of vertical resolution. The model has integrated with and without two-way nesting for 30 years (1979～2009) forced with sea surface temperature and sea ice concentration as boundary condition based on AMIP type simulation. And the seasonal prediction for June-July-August 2016 has integrated.

P-084

Impacts of changing WRF model grid spacing, cumulus physics and microphysics in predicting weather systems in Tanzania

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Tanzania is an East African nation covering 947,303 square kilometers located between latitudes 10-120 S and longitudes 280-420E. Being located in tropical areas, Tanzania's weather concern is more about precipitation than temperatures and surface winds and these two variables do not vary much throughout the year.

Rainfall is a very important climate phenomenon that affects social and economic activities in Tanzania. The economy of Tanzania is mainly dependent on rain fed agriculture, which is highly vulnerable to the amounts and distribution of rainfall. On the other hand, excessive rainfall also has negative influence on the social-economic activities of Tanzanians as it may lead to floods, loss of lives, and damage to property. Therefore, timely and accurate forecasts of rainfall are very important for the people of Tanzania.

The Tanzania Meteorological Agency uses Weather and Research Forecasting (WRF) model among others in developing its forecasts and issuing to the public. In order for the model to provide accurate forecasts, good combination of physical parameterization and horizontal grid spacing (resolution) is needed for each season.

In this ongoing study, the skill of the mesoscale model WRF in forecasting precipitation over Tanzania, and its sensitivity to physical parameterization schemes and horizontal grid spacing (resolution) during heavy rainfall and dry seasons is being assessed.

There is a default configuration of the model currently running operationally in Tanzania Meteorological Agency. In this study, the altered configurations are experimented in order to evaluate the skills of the changed settings. The altered experimental configurations consist of changed sets of physical parametrization schemes and horizontal resolutions. The selected microphysical schemes include Lin et al scheme in a control setting, Kessler and WRF Double Moment 6 class schemes in experimental settings. The selected cumulus physics schemes include Multi scale Kain-Fritch scheme in control setting, Bett Miller Janjic, Ensemble Grell 3D and Old version of Kain Fritsch schemes in experimental settings. The control setting of horizontal grid spacing is 15Km for the outer domain and 5Km for the inner nested domain, respectively, and the experimental settings is 12/4Km and 6/2Km for the outer/inner domains.

The experiments are conducted by altering these settings and accessing the forecasting results produced by each setting against observation by calculating statistical scores so as to access the skill of the model.

The Preliminary results show that there is not much difference in the sensitivity studies of the above model configuration over the coastal regions of Tanzania. This is believed to be due to the fact that most of the precipitation activities along the coastal region are due to synoptic scale phenomena which are nowadays precisely handled by NWP systems. However, for the inland locations, the higher resolution configurations are shown to have higher skill scores than the relatively lower ones.

Also, the combinations containing the WRF Double Moment 6 class microphysics schemes are shown to have improved skills.

In other cases, especially for those characterized by local features, most of the model combinations had very poor skills. These included areas where there were forests, topographic features, and inland lakes like the Lake Victoria region.

Generally, it might be concluded that increasing grid spacing improves skill of the model, especially in depicting local convective systems, and that the control settings as currently used by Tanzania Meteorology of using Multi scale Kain-Fritch Cumulus physics scheme and Lin et al Microphysics scheme has poor skills.

P-085

Multi-model Ensemble Improves Precipitation Prediction in Solomon Islands

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A number of downscaling methods have been developed to overcome some of the challenges of using Regional to Global Climate Models (GCM) in simulating local climate conditions. They can be categorized into two types: one method is dynamical downscaling and the other is statistical downscaling. Dynamical downscaling uses high resolution simulations using a regional climate model, which in turn is driven by the outputs of a coarser resolution GCM. This method has the potential to simulate extreme events. This method is computationally expensive and a lot of storage space is required for achieving model outputs. The other approach is statistical downscaling. The goal is to discover a stable relationship between GCM outputs and a variable of the local climate. This relationship is used to predict elements of the regional climate using GCM products and has come to be widely used because of its lesser computational requirement. It has been investigated and shown by previous researchers that the Multi-Model Ensemble technique can improve the seasonal predictions by reducing the uncertainties associated with individual models. The statistical approach carried out in this study is a simple regression projection downscaling method to predict wet and dry season precipitation at 7 stations in the Solomon Islands. The potential variables selected include the precipitation (prec), the temperature at 2 meters (t2m), the sea level pressure(slp), the 850-hPa wind velocity fields (u850 and v850), the air temperature at 850hPa (t850) and the 500hPa geo-potential height(z500). The predictand is the precipitation amount at 7 synoptic stations. The hindcast data set was from the period of 1983-2005 with one month lead time. This hindcast data set was interpolated on a 2.5^{o} x 2.5^{o} grid for analysis. NCEP2 data were also used in this research to examine the correlation with the station rainfall and also Simple Composite Data (SCM) from MME. The study investigates the correlation between station precipitation with NCEP2 and MME (SCM) for the dry season (June-August) and wet season (December-February), as well as the transitional periods for each of the 7 stations. The downscaling method is only applied to the SCM data with station precipitation and not with the NCEP2 data and precipitation. The variable(s) with the highest correlation coefficient(s) are identified and used for predicting station precipitation for the seven stations.

There are three rainfall stations investigated so far: Auki in the central region, Lata in the eastern region and Munda in the western region. According to the analysis done so far the variable 500hPa geo-potential height (z500) was found to predict precipitation well for both the dry and wet season at the three stations in Solomon Islands. This suggests that z500 can be used as a good predictor to predict seasonal precipitation in Solomon Islands. Also other variables such as sea level pressure, temperature at 850hPa and wind velocity have also shown good skill predictability. With improved identification of the useful predictors, forecast predictions can be analyzed to evaluate the accuracy of forecasting as below normal, normal and above normal precipitation.

P-086

Seasonal Streamflow Forecasting Development for Angat Reservoir

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Seasonal streamflow forecasting is of great benefit for water management and planning. As well as setting up early warning systems for extreme hydro-meteorological events such as drought and extreme rainfall. Every year an average of 19-20 tropical cyclones affect the Philippines that brought above normal rains in specific areas. Changes in the sea surface temperature also alter the normal distribution of rainfall in the country. For water management, surplus of water may force dams to released water while reduction of it may cause regulating some of its main function. Planning these months ahead may help proper water management in the reservoir. However, further study on forecasting seasonal streamflow needs to be undertaken in the Philippines. For this reason, a streamflow forecast methodology for the Magat Watershed in the Philippines needs to be developed. With the main objective of establishing a seasonal streamflow forecasting methodology using statistical-based empirical model approach that can help water managers to assess the effects of rainfall/streamflow variability on the watershed to effectively manage dam operations.

The methodology used in the study consists of searching for the potential reservoir streamflow predictors and reduce the number of these predictors by evaluating its significance on the reservoir inflow using the criteria of Pearson's correlation at $-0.4<r<0.4$ range and a p-value test of $p<0.05$ from January-December (1983-2007). A lag correlation between the predictors and the predictand was also established to further determine the significance of each predictor. In this study, 12 possible predictors both oceanic and atmospheric predictors were evaluated, consisting of Sea surface temperature (Niño 1+2, Niño 3, Niño 4, Niño 3.4 SST's) as oceanic predictors, Southern Oscillation Index (SOI), rainfall, Outgoing longwave radiation (OLR), wind speed (Zonal and Meridional wind) at 850 hPa (UV850) and (Zonal and Meridional wind) at 300 hPa (UV300), and Geopotential height as atmospheric predictors. Based on initial findings, the study will focus on months of (January-May) and (October-December) where the criteria for choosing the possible predictors for forecasting the streamflow were reached. For seasonal streamflow forecasting, statistical prediction models such as Principal Component Regression (PCR) and Multiple Linear Regression (MLR) will be evaluated using both atmospheric and oceanic predictors.

The results obtained suggest that for the months of January to May, among 12 predictors, 5 predictors, namely: Rainfall, Niño 3.4/Niño 4, SOI, OLR, and U850 or U300 meet the criteria and these can be used as predictors because they tend to explain most of the streamflow variability. While from October to December, among 12 predictors, 5 predictors, namely: Rainfall, Niño 3.4/Niño 4, OLR, SOI, and U300 or V300 met the criteria and they can be used for predicting the streamflow during this season. Furthermore, preliminary results suggest that using these predictors to generate an MLR model or PCR model to predict the seasonal streamflow in the reservoir may bring significant benefits. Thus, the generated regression model using multiple predictors to forecast the streamflow suggests an overall increase in Pearson's correlation compared to a model with only one predictor. These findings may suggest a further increase in the accuracy of the forecast.

Furthermore, the established streamflow forecast model for the chosen months will be further validated. Moreover, additional research for seasonal streamflow forecast during the high flow season (June-September) in the study area is being carried out.

Key words: Seasonal streamflow, Principal component regression, Multiple linear regression

P-087

Polarimetric Signatures of Selected Tornadic and Nontornadic Thunderstorms in the Philippines

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Tornadic activities spawned by severe convective storms in the Philippines are becoming more frequent and damaging. Despite their impacts, there have been no intensive scientific studies conducted to substantiate findings on the occurrences of tornadic storms.

The emergence of dual-polarimetric radars offers a powerful method to analyze the microphysical and dynamical processes of severe convective storms. Electromagnetic radiation, in both horizontal and vertical directions, provides a more defined and detailed information of the target- its type, shape and variety of targets. It enables scientists to conduct an in-depth analysis of mesocyclogenesis and define characteristics of thunderstorms by closely analyzing polarimetric variables, areas of strong updraft, forward-flank downdrafts (FFDs) and rear-flank downdrafts (RFDs), among others. This study aims to investigate the microphysical and dynamical features of selected cases of tornadic and nontornadic thunderstorms in the Philippines using polarimetric observation data. Furthermore, it also aims to distinguish and compare distinctive characteristics of tornadic thunderstorms in the Philippines with some known features of tornadic storms in Great Plains (USA), Japan and South Korea. This study employs the use of Simultaneous Dual-Polarization (SIDPOL) C-Band radars stationed at Mactan, Cebu and Tagaytay City.

The lowest scan data with better quality are used in this study. Polarimetric variables have been carefully studied such as Reflectivity Factor at horizontal polarization (ZHH), Differential Reflectivity (ZDR), Doppler Velocity (VH) and the magnitude of the copolar Cross-Correlation Coefficient (ρHV). Schematics of polarimetric signatures using C-Band radar at low levels were developed to provide better analysis on the concentration of each polarimetric variable with certain threshold values for low, medium and high values for tornadic and nontornadic storms. Moreover, possible explanation on the developments of tornadic storms is presented. Wilcoxon-Mann-Whitney (WMW) tests were used to discriminate features of similar variables between tornadic and nontornadic events; Kruskal Wallice tests were employed to determine the statistical significance of the four polarimetric variables before, during and after tornado event.

The result shows significant differences in the distribution of all variables including median differences during tornadic and nontornadic events hence rejecting null hypotheses. Anomalously low ZDR and ρHV with relatively high ZHH were observed within the immediate vicinity of the tornado location. ρHV consistently shows good discriminating power during tornado events compared with the other variables. High ZDR values near tornado vortex maybe associated with the presence of large rain drops. Moreover, initial finding explains that Philippine tornadoes, in most cases, have been found to be generally short-lived and weak which do not significantly loft debris compared with those found in the United States. Due to limited polarimetric observations of tornadic events since the installation of radar in the Philippines, the results should not be overgeneralized. However, findings from this paper can serve as a preliminary attempt to foster future studies. Likewise, the results provide a basis for operational meteorologists to identify severe weather threats such as presence of hail and tornadoes by closely analyzing various polarimetric variables. Additional studies taking into account other polarimetric variables while considering analysis of the whole volume scan of the radar data will be important in the future.

P-088

Characteristics of East Asian extratropical cyclones in CMIP5 models

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Extratropical cyclones (ETCs) in East Asia and their future changes are examined by using multi-model data sets archived for the Coupled Model Intercomparison Project phase 5 (CMIP5). For both historical and Representative Concentration Pathway 8.5 (RCP8.5) simulations, East Asian ETCs are objectively detected and tracked with an automated Lagrangian tracking algorithm. This algorithm, which is applied to 850-hPa relative vorticity fields subject to spatial filtering of wavenumber 5-42, identifies several ten thousands of synoptic-scale cyclones in each model for the periods of 1979-2004 and 2074-2099.

Most historical simulations qualitatively well reproduce overall characteristics of East Asian ETCs. Although slightly underestimated in quantity in comparison to reanalysis, spatial distribution and seasonal cycle of ETC genesis, frequency, and intensity are well captured. A noticeable exception is an overestimated ETC intensity over the Southern China and along the coastline. This exaggeration, which is not sensitive to the model resolution, is largely associated with weak static stability biases over the continent and cold sea surface temperature biases along the coastline. Regardless of model biases, most models predict that frequency and intensity of ETCs would decrease in a warm climate especially over the western North Pacific. The reduced number of ETCs over the continent and ocean is particularly robust across all models. This is due to weakened cyclogenesis downstream of southeastern Tibetan plateau and across Kuroshio current, likely caused by enhanced static stability and reduced sea surface gradient in a warm climate. It is further found that because of vertical wind shear change in summer, weakening and reducing of East Asian ETCs are most evident in summer than in any other seasons.

P-089

Simulation of diurnal cycle of boreal summer precipitation by GEOS-5 with high horizontal resolution

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Diurnal cycle of precipitation for boreal summer is general phenomenon of global climate and weather systems, and has great effect on the human activity. Previous studies have explained that maximum precipitation over land and ocean occurs generally in the late afternoon and the early morning, respectively. In addition, spatial distribution of the diurnal phase varies on the topography like the mountain, coastline, and so on. However, the recent numerical models have difficulty to simulate the diurnal cycle realistically. To improve reproducibility of the diurnal cycle in many models, there have made a lot of effort, and increase of horizontal resolution is considered as one of the solutions for the improvement. Thus, this study validated the representation of global diurnal cycle of precipitation in warm-season simulated by the GEOS-5 AGCM that has high spatial resolution, 10 km compared with the observation data. For the validation, the TRMM 3B42 satellite precipitation data and MERRA reanalysis wind field data are used, and the period of the simulation and the observation is June to August for 2 years (2005-2006). Simulated results by the GEOS-5 are similar seasonal mean pattern and diurnal amplitude of global precipitation although the amount and amplitude over land (ocean), especially mountains, are overestimated (underestimated) in comparison to the observation. In addition, impact of the diurnal amplitude on the seasonal mean precipitation over the tropics and mid-latitudes is well represented in the model except some regions, for example, Central America in the tropics and the Tibet, the Rocky Mountains, and the Great Plains in the mid-latitudes. Spatial distribution of the diurnal phase that is the time of maximum precipitation is very similar to the observed distribution, moreover, the model mimics the phase over regions with complicated terrain and curvy shore. The total precipitation over land simulated by the model is more affected by the convective precipitation rather than the precipitation led by large-scale circulation though the peak over ocean occurs about 5 hours earlier in the model. And, the nocturnal precipitation over land is caused mostly by large-scale precipitation. Diurnal cycle of precipitation over 6 regions, North America (the Great Plains), Central America, the northern part of South America, Indochina Peninsula, Maritime Continent, and the northwestern region in Africa, are investigated, and these regions have been mentioned as the regions where show the apparent diurnal cycle in the previous studies. The model tends to describe the diurnal variation, phase, and amplitude reasonably, but the amplitude of diurnal precipitation over most land regions is overestimated. The deficiencies of the warm-season diurnal precipitation in the simulation are remained although the GCMs have very high horizontal resolution approximately 10 km, and simulates diurnal variation of precipitation quite reasonably. Therefore, the improvement of the physics in the model, such as convective parameterization, is needed to describe the intensity, phase, organization, and propagation of small-scale convective systems over complex terrains more realistically.

P-090

Impact of Two Types of El Nino on Tropical Cyclones over the Western North Pacific: Sensitivity to Location and Intensity of Pacific Warming

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The effect of ENSO on tropical cyclones (TCs) has not been fully explored, especially in terms of ENSO and the impact of various warm phases. This study looks at the effects of two different warm phases: the eastern Pacific (EP) El Nino and the central Pacific (CP) El Nino. The study investigates the impact of central and eastern Pacific warming on TCs over the western North Pacific (WNP) for the period 1948-2015. WNP TC activity related to ENSO shows stronger sensitivity to the intensity of SST warming in the CP. The locations of TC genesis in an extreme EP El Nino associated with concurrent strong CP and EP warming (CEPW), displaying notable southeastward shift, are generally similar to the CP El Nino associated with CP warming alone (CPW). These influences are clearly different from the effects of moderate EP El Nino associated with EP warming alone (EPW). Anomalous convection associated with CP SST warming drives anomalous low-level westerlies away from the equator as a result of Gill-type Rossby wave response, leading to an enhanced broad-zone, eastward-extending monsoon trough (MT). Anomalous Walker circulation in response to EP SST warming drives an increase in anomalous equatorial westerlies over the WNP, leading to a narrow zone, slightly equatorward shift of the eastward-extending MT. These changes in MT coincide with a shift in large-scale environments and synoptic-scale perturbations, which favor TC genesis and development. In addition, during phases of weaker EP SST warming (WEPW) of similar intensity to CPW, WNP TCs and atmospheric circulation in response to SST forcing is localized.

P-091

A skillful prediction model for winter NAO based on Atlantic sea surface temperature and Eurasian snow cover

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A new statistical forecast scheme, referred to as Scheme 1, is developed using observed autumn Atlantic sea surface temperature (SST) and Eurasian snow cover in the preceding autumn to predict the upcoming winter North Atlantic Oscillation (NAO) using the year-to-year increment prediction approach (i.e. DY approach). Two predictors for the year-to-year increment are identified that are available in the preceding autumn. Cross-validation tests for the period 1950-2011 and independent hindcasts for the period 1990-2011 are performed to validate the prediction ability of our technique. The cross-validation test results for 1950-2011 reveal a high correlation coefficient of 0.52 (0.58) between the predicted and observed year-to-year increment of the NAO index. The model also successfully predicts the independent hindcasts for the period 1990-2011 with a correlation coefficient of 0.55 (0.74). In addition, we also establish Scheme 0 (i.e. Anomaly approach) using the SST and snow cover anomalies in the preceding autumn. Compared with Scheme 0, our new prediction model has higher predictive skill in reproducing the interdecadal variability of NAO, which represents an important advantage of Scheme 1. Therefore, this study provides an effective climate prediction scheme for the interannual and interdecadal variability of NAO in boreal winter.

P-092

Comparison of satellite-estimated and model-forecasted rainfall data during a deadly debris- ow event in Zhouqu, Northwest China

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The data of several rainfall products, including those estimated from satellite measurements and those forecasted via numerical weather modeling, for a severe debris- ow event in Zhouqu, Northwest China, are compared and analyzed in this paper. The satellite products, including CPC MORPHing technique (CMORPH), TMPA-RT, and PERSIANN are all near-real-time retrieved with high temporal and spatial resolutions. The numerical weather model used in this paper for precipitation forecasting is WRF. The results show that all three satellite products can basically reproduce the rainfall pattern, distribution, timing, scale, and extreme values of the event, compared with gauge data. Their temporal and spatial correlation coe cients with gauge data are as high as about 0.6, which is statistically signi cant at 0.01 level. The performance of the forecasted results modeled with di erent spatial resolutions are not as good as the satellite-estimated results, although their correlation coe cients are still statistically signi cant at 0.05 level. From the total rainfall and extreme value time series for the domain, it is clear that, from the grid-to-grid perspective, the passive microwave-based CMORPH and TRMM products are more accurate than the infrared-based PERSIANN, while PERSIANN performs very well from the general point of view, especially when considering the whole domain or the whole convective precipitation system. The forecasted data - especially the highest resolution model domain data - are able to represent the total or mean precipitation very well in the research domain, while for extreme values the errors are large. This study suggests that satellite-retrieved and model-forecasted rainfall data are a useful complement to gauge data, especially for areas without gauge stations and areas not covered by weather radars.

P-093

Using random forest algorithm to estimate spatial variability in surface climate fields in China

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We have developed a method to create high-resolution land surface data using random forest algorithm by integrating different sources of publically available datasets, including reanalysis data, topography data and ground observation data. Although some land surface fields (especially temperature) have been already produced, there are still cases in which observation datasets have been damaged due to lack of maintenance of observation facilities. Therefore, it is necessary to produce land surface climate datasets using statistical approaches and an extensive number of publically available datasets for cases in which ground observation stations are unable to continuously observe and precisely report when accidental damage happens. On the other hand, in the current big data era, it is also feasible to produce high-resolution climate datasets by random forest algorithms utilizing these publically available datasets, including new satellite or reanalysis data, in order to improve the results. In this study, we designed historical daily climate datasets by using random forest algorithms. These datasets include maximum temperature, minimum temperature, mean temperature and wind speed. Taking mean temperature variable as an example, we first considered datasets derived from international observatories where there are 194 total stations from 2006-01-01 to 2012-12-31 use as training datasets. We then randomly picked several pieces from this training dataset's records to train the random forest algorithm. The random forest algorithm estimates out-of-bag errors spatially and yields the relative importance of each of the input variables. Finally, we used the well-trained model to estimate daily mean temperatures from 2013-01-01 to 2016-12-31. This method has two advantages: 1.) the method is purely statistical so that physical assumptions are not required and 2.) since a random forest is conducted from a set of K deterministic trees, which based on a random sample of training data, are not necessary for making relative analyses before the training process begins; this is different from other algorithms such as support vector machines or artificial neutral networks. Also, because of the ensemble features of random forest, there are several pieces of low quality records in incoming data; however, this should not cause critical bias in the results. As a result, users do not need to pay special attention to quality control of input data compared to other assimilation methods. In conclusion, the proposed method should be able to produce reasonably high-resolution data and thus can provide researchers with a set of more accurate historical climate datasets, which can facilitate better results in regional models.

P-094

A Numerical Study ob the Effects of Wind Fences on Surface Winds around the Jang-Bogo Antarctica Station

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Terra Nova Bay, near the Jang Bogo Antarctic Research Station is one of the best places for studies on katabatic wind, because strong katabatic winds often appear around the bay. To analyze the three dimensional flow characteristics around the Jang Bogo Antarctic Research station, the influence of Jang-Bogo Antarctic Research Station on detailed flow, and the effective wind-fence conditions on the surrounding observation environment, a computational fluid dynamics (CFD) model was used. To investigate the flow characteristics altered by the Jang-Bogo station, we conducted simulations for 16 cases with different inflow directions and, for each inflow direction, we compared the flow characteristic with those simulated after the construction of the Jang-Bogo station. The observation data of automatic weather system (AWS) were used for comparison. The wind-roses analysis showed that the wind speeds and directions after the construction were quite different from those before the construction. We also investigated effects of wind fences on the reduction of wind speeds around the Jang-Bogo station to see how effectively the wind fences reduced wind speeds inside the Jang Bogo station. For this, we changed systematically the distance between the fences and the Jang-Bogo station (2H～8H with the increment of 2H, H is fence of height) and porosity of fences (0%, 25%, 33%, 50%, 67%, and 75%).Because the AWS was located in the east of the Jang Bogo station, the effect of the construction could be maximized in the affiliated westerly cases [e.g., in the west-northwesterly case, the wind speed decrease was maximized (81% compared to the wind speeds before the construction)]. In the case that the distance between the wind fence and the Jang-Bogo station was 2H, the wind speed reduction was maximized. At the same distance, the fence with the porosities of 25～33% maximized the wind speed reduction. We expect that the result gives guidelines in evaluating the suitability of the AWS location and it recommend proper locations at which AWSs should be installed as a representative observation site around the Jang Bogo Antarctic Research Station. Also, the result suggests optimal the wind fences to protect researchers and properties in the Jang-Bogo station from the potential damages caused by the strong katabatic winds

P-095

Effects of Surface Temperature on flow and air temperature in an urban area

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In this study, the effects of building and ground surface temperatures on surrounding flow and air temperature at the Seoul automated synoptic observing systems (ASOS) located at Songwol-dong, Jongno-gu, Seoul were analyzed. Based on cloudiness data observed at the Seoul ASOS, we selected the period (0000 LST 3 - 2300 LST 4 August 2012) when clear sky persisted and solar radiation could reach the ground surfaces. A computation fluid dynamics (CFD) model coupled to the local data assimilation and prediction system (LDAPS) was used for reflecting the local meteorological characteristics in CFD model simulations. In the area around the Seoul ASOS, high-rise buildings are located in the east and big apartment complexes on the west of the Seoul ASOS. Mountains are located in the northwest and southwest. To reflect the realistic topography and urban structures such as buildings, GIS data with the horizontal resolution of 1 m × 1 m was used. Also, land cover data with the same resolution as GIS data was used and it was classified into five major types (concrete, asphalt, green, bare land, and water areas) to assign different surface temperatures to each land type. Time variation of temperatures on solid surfaces was calculated using observation data at El-Oued, Algeria of which latitude is similar to that of the target area. Considering land-use type and shadow, surface temperatures were prescribed in the LDAPS-CFD coupled model. In order to examine how well the LDAPS forecasted the selected cases, we compared the simulated weather charts over the Korean Peninsula to the observed one. The LDAPS reasonably well forecasted the MSLP field for the period. The LDAPS overestimated the observed wind speeds and underestimated the observed air temperatures.. However, a coupled LDAPS-CFD model relatively well reproduced the observed wind speeds and air temperatures, considering complicated flows and surface temperatures in the urban area. In the morning when the easterly was dominant around the target area, both the LDAPS and coupled LDAPS-CFD model underestimated the observed temperatures at the Seoul ASOS. This is because the Kyunghee Palace located at the upwind region was composed of green area and its surface temperature was relatively low.

P-096

Analysis of Ice and Snow Failure on Transmission Line Using Synthetic Data

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It is a trend to construct high-voltage transmission lines using mountainous areas with low distribution of observation stations by bypassing residential concentration areas. When icing occurs on the high-voltage transmission line and the communication line in mountainous areas during the winter, a galloping phenomenon occurs in which the transmission lines strike each other by the wind. When the high voltage transmission line is disconnected due to the galloping phenomenon, it causes a problem in power supply, so it is necessary to analyze the weather when the galloping phenomenon occurs.

A recent study, to analyze the weather conditions in the case of a galloping accident, they used the nearest AWS meteorological data the transmission line. However, it is not possible to obtain the accurate meteorological data on the transmission line when using nearby AWS weather data because the meteorological data is affected by surrounded terrain.

In this study, we used the quantitative precipitation model (QPM) and the quantitative temperature model (QTM) to estimate the topographical effects and restore the temperature and precipitation by 1 km resolution for the Korean Peninsula. The synthetic data was analyzed for a month. The target transmission line is located at an altitude of about 1200m which is a place vulnerable to accidents.

As a result, there was an average of 10.2 mm of precipitation between January 17 and 21, 2012, and the temperature range was -11.2～0.9℃. Before the accident, the weather is a good environment for hard rime. Hard rime is highly adhesive and has high density and occurs over several days. Therefore, it is presumed that the damage caused by ice and snow failure on this transmission line is due to the hard rime which lasted for three days.

P-097

A Study on the Characteristics of Atmoshere Electric Field Using Sensors for Measuring the Atmospherer Electric Field

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In the atmosphere, thunderstorms are formed by rising air currents, and thunderstorms disappear by earth discharge or lightning. An electrostatic field occurs in the atmosphere due to the thunderstorms, and the electric field strength fluctuates due to the lightning discharge. In the case which the lightning discharge does not occur, the electrostatic field by the thunderstorms can be measured by using the field mill, but it is very complicated to measure the electric field strength by attaching the field mill to the instrument to be flown, so that it can't be applied. Therefore, in this study, the electric field strength according to the altitude was measured through the production of sensors for measuring the atmospheric electric fields.

A flat-type sensor having a high receiving sensitivity was used for the detecting electrode of the sensor for measuring the atmospheric electric field, and in the examination results of detecting the electric field strength, the response sensitivity has linearly correlated sensitivity, and in the cryogenic test, the operation characteristics were constant when the sensor was continuously exposed at -50℃, and the lithium ion battery was used as a power source.

The detected sensor signals were transmitted to the ground using a commercial radiosonde, and signal processing was performed by making the data collection unit for the sensor interface, and the effective section of the atmospheric field strength signals was observed at an altitude of about 6km through the flying test, and lastly at the point where the humidity value decreased significantly during the flying, the strong negative(-) value of the field strength signals was observed, showing the characteristics of the cloud edge. In addition, cumulonimbus cloud appeared in certain sections when flying the sensor for measuring the atmospheric electric fields in the condition that humidity near the surface is high. As a result of comparing the ground electric field observing equipment with the lightning detection system in order to confirm the correlation with the occurrence of lightning stroke, it was confirmed that the strong electric field strength signals in the effective section is related to the occurrence of the lightning stroke.

Since thunderstorm form a single convective cell due to the upward and downward movement of the air currents, they constitute the basis of thunderstorms. Therefore, in order to analyze the convective phenomenon of thunderstorms, a measurement height above the troposphere interface is required. Therefore, additional research is needed to increase durability and attitude control to improve sensor sensitivity.

P-098

Assessment of Atmospheric Stability Products derived from Satellite Images over Korea peninsula

Jong-Sung Ha (Korea Aerospace Research Institute)

Stability indices in meteorology are used to quickly assess the susceptibility of the atmospheric to severe weather and a measure of the atmospheric static stability. These indices are calculated from the vertical observation of the atmosphere, and a radiosonde observation has been mainly utilizing. A radiosonde carried into the atmosphere by a weather balloon can measure various atmospheric parameters and transmits them by radio to a ground receiver. The upper air data from radiosonde is very useful for the interpretation of the atmosphere's vertical thermodynamics profile of temperature and moisture as well as kinematics of vertical wind profile. Despite these advantages, due to the use of balloon and frequency to receive data, there is spatial limit and difficulty in continuous observation. Also, the profile obtained by the radiosonde does not represent the vertical profile over a single point on the earth and may contain the effect of changes in the horizontal plane. On the other hand, satellites can provide spatial-temporal distribution of various atmospheric parameter. Therefore, atmospheric profile data from satellite could be good replacement for radiosonde.

The objective of this study is to examine the potential of satellite remote sensing in assessing atmospheric instability. Atmospheric instability was assessed by calculating the spatial distribution of Stability Indices. In this study, six stability indices like Showalter Index[SSI], K Index[KI], Lifted Index[LI], Total Totals Index[TTI], Humidity Index[HI], and Deep Convective Index DCI] were used. Also, CrIS[Cross-track Infrared Sounder]/ATMS[Advanced Technology Microwave Sounder] and MODIS onboard Suomi-NPP and Auqa respectively were used to estimate atmospheric temperature, humidity and geopotential height profiles. Finally, Radiosonde derived instability indices, at six meteorological stations in South Korea, were used for validation. Analysis was conducted over Korea peninsula for summer season (June to August) in 2014. First, I conducted an analysis of dry bulb and dew point temperature vertical profiles with CrIS/ATMS, MODIS, and radiosonde. And then, Stability Indices (hereinafter SIs) derived from two satellites were compared with corresponding values derived from radiosonde observation, with the purpose of evaluating the retrieval ability to assess atmospheric stability.

Almost all values of the vertical profiles were in good agreement with Satellite data in comparison with the radiosonde data as well as between the two satellites. The Correlation Coefficient (hereinafter CC) for the dry bulb temperature profile between satellite and radiosonde data was 0.99 or more and for the dew point temperature was 0.97 or more. So satellite atmospheric profile product could be used in the regions where radiosonde data is absent. Statistical analysis showed the satellite-based indices correlate very well with the same indices derived from the radiosonde data, correlation coefficients being between 0.4 and 0.78. Especially, the correlation of all SIs from CrIS/ATMS were higher than MODIS SIs. MODIS has availability of retrieved profiles generally under clear-sky conditions, while CrIS/ATMS can obtain them from IR sounder measurements under cloudy conditions. Therefore, CrIS/ATMS is more useful in the prediction of convective activity and thunderstorm. KI from CrIS/ATMS presented the best performance with a correlation coefficient 0.78 in comparison with the radiosonde data. The correlation of DCI, TTI, and HI were a litter lower and comparable.

P-099

Future change of Northern Hemisphere Blocking in CESM Large Ensemble simulations

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The Northern Hemisphere (NH) blocking and its future change are investigated using forty ensemble simulations of Community Earth System Model (CESM). The historical simulations qualitatively reproduce the spatial distribution of NH blocking frequency. However, ensemble spreads are substantially large with significantly underestimated Euro-Atlantic (EA) blockings but overestimated North Pacific (PA) blockings. These dipolar biases, which are largely associated with the model mean biases, are remarkably similar to those in climate model simulations archived for the Coupled Model Inter-comparison Project phase 5 (CMIP5). The future climate simulations, driven by Representative Concentration Pathway 8.5 (RCP 8.5) scenario, further reveal that overall blocking frequency may decrease in a warm climate. Such a decline is hinted for PA blocking in all duration categories, whereas decrease in EA blocking mainly appears in relatively short-lived events. A clear exception is the western Russia where blocking frequency is projected to increase in a warm climate, possibly due to the Arctic sea ice loss. This result, which is particularly robust in cold season, is consistent with previous studies on the CMIP5 models.

P-100

2015 Korean drought: Its cause and mechanism

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In 2015, Korea experienced relatively strong drought, and annual mean precipitation was the third lowest since observation started at 1969 causing adverse impact on the several sectors including farming industry. Most precipitation in Korea occurs during summer season. In case of 2015 Korean drought, summer rainfall was much below normal. Weather and climate in Korea is largely controlled by the East Asian Summer Monsoon (EASM). Thus, it is important to understand how 2015 Korean drought was formed and maintained from the perspective of the variability of the EASM.

This study utilizes atmospheric water budget. In short, area-averaged precipitation is equal to evapotranspiration minus of atmospheric water vapor flux ignoring atmospheric water vapor storage term where is evapotranspiration, and is the divergence of atmospheric water vapor flux.

The EASM ha various interannual variabilities such as the Pacific-Japan pattern (PJ pattern). For example, Central China, Korea, and Japan is wet and cool in summer when the PJ pattern is positive, and vice versa. Here, we can understand how the PJ pattern influences 2015 Korean drought. The PJ pattern could be correlated with El Niño-Southern Oscillation (ENSO). Thus we need to understand how both phenomena affect 2015 Korean drought.

Our analysis shows anomalous atmospheric circulation preventing the rain-band moving to the Korea. Also, negative precipitation anomaly was developed in the north and south of the rain-band, similar as the PJ pattern.

P-101

Long-term change of the tropical cyclone tracks and potential impacts over the southern region of Vietnam

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Vietnam is considered as one of the countries most affected by climate change. Over the past several years, tropical cyclones (TCs) generated from the South China Sea have increased and more landfall over Vietnam causing socio-economic damage and negative impacts on the environment. There are many previous studies on TC activity and its impacts in the central part of Vietnam, while the southern region has been received little attention despite high vulnerability of this area. This is due to several factors: population density is very high along the coastal region and the public awareness on disaster impacts is quite low. Furthermore, the main season rice crop is the same time with winter monsoon period and TC season over this region.

In this study, the historical data of TCs with their tracks and intensity for last 50 years including the International Best Track Archive for Climate Stewardship (IBTracks) and one from the Joint Typhoon Warning Center (JTWC) is analyzed to find the seasonal and interannual variations of TCs affecting the southern part of Vietnam. This information will be used as the base for any mitigation and adaptation.

P-102

Effects of spectral nudging on the simulated summer surface air temperature compared with different physics in a high-resolution regional atmospheric model

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The impact of a spectral nudging technique for dynamical downscaling on surface air temperature in a high-resolution regional atmospheric model is assessed. The performance of this technique is measured by comparing with 16 simulation sets of physical parameterization combinations of two shortwave radiations and four land surface schemes, which are known to be crucial for the simulation of the surface air temperature. It is found that the application of spectral nudging to the outermost domain has a greater impact on the regional climate than any combination of shortwave radiation and land surface schemes. The spectral nudging provides a more accurate lateral boundary condition to the innermost domain by securing consistency with large-scale forcing over a regional domain. This consequently indirectly helps two types of physics to produce small-scale features closer to the observed value, leading to a better representation of surface air temperature in high-resolution downscaled climate.

P-103

WISE UMS-Seoul based local circulations in the Seoul Metropolitan Area

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The UMS-Seoul (Urban Meteorological observation System in the SEOUL metropolitan area) is one of the most intensively integrated urban meteorological observation networks in the world for high-resolution and high-quality meteorological information service customized for users' demand in the Seoul Metropolitan Area (SMA). In this study, the detailed local circulation patterns in the SMA for the period from 18 to 20 May 2016 are analyzed with the use of UMS-Seoul observation data. Horizontal distribution of temperature and pressure show that the SMA is strongly affected by the local circulation such as land-see breeze and urban-rural breeze. Sea breezes (westerly winds) are dominant from afternoon to early evening, while land breezes (easterlies winds) are dominant from late evening to early morning. Steep horizontal temperature gradient line and winds indicate that the sea breeze front passes Seoul Special City from west to eastward at a rate of about 10 km h-1 on 19 and 20 May 2016. The higher temperature (the lower pressure) in urban area than in the surrounding rural area can be a strong evidence on the urban heat island and a strong candidate of convective storm track paths. Vertical profiles of wind show that land breeze evolves to between 500m and 1000m altitude before dawn and see breeze evolves to 1.3 km altitude late afternoon. Finally, vertical profiles of atmospheric attenuation obtained with ceilometer and meteorological variables obtained with wind lidars and microwave radiometers shows that the mixing-layer heights show a diurnal variation with a maximum in late afternoon and a residual layer is often located over the top of mixing-layer in the evening.

P-104

Numerical Experiment Analysis of the West Coast Heavy Snowfall Development Mechanism

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In 23～25, January, 2016, a heavy snowfall event occurred along the southwest coast region and 18.4cm of snow amount fell in Jeju Island during the period. The west coast snowfall is typically caused by the modification of Siberian air mass trailing over the Yellow Sea during winter time. This study examined the lake effect of the Yellow Sea on the Siberian High pressure system, and the development mechanism of the convective cells over the ocean.

The numerical experiments are performed using the Weather Research and Forecasting (WRF) - Advanced Research WRF (ARW) model ver. 3.7.1. Experiments consist of the control experiment (CTL), and an experiment changing the yellow sea to dry land (EXP), to find the effect of the Yellow Sea on the west coast heavy snowfall event. Dynamical and thermodynamical analyses of WRF model simulations are performed. Relative vorticity and convergence at the surface layer, equivalent potential temperature, depression of dew point, wind vector, latent heat flux and sensible heat flux at the surface layer are analyzed in detail. The CTL simulation result showed distinct high area of relative vorticity and convergence than that of EXP. Because of the absence of the Yellow Sea, air-sea temperature difference is smaller and diabatic heating is insufficient in EXP compared to CTL. In CTL, low level atmospheric instability is larger than EXP. This indicates that large surface vorticity and convergence induced vertical motion and low level instability over the ocean. The latent heat flux and sensible heat flux change were also noticeable. When cold and dry Siberian air mass moves south over the Yellow Sea, sensible heat flux at the sea surface gradually decreased. On the other hand, latent heat flux gradually increased. This indicates that, at the beginning stage of air mass modification, sensible heat was the main energy source for convective cell generation. In the later stage, latent heat became the main energy source for the development of convective cells.

In conclusion, the mechanism of the west coast heavy snowfall caused by modification of the Siberian air mass over the Yellow Sea is due to from air sea interaction. a) Cyclonic vorticity caused by diabatic heating which induce Ekman pumping and convergence at the surface. b)Sensible heat and moisture flux at the sea surface producing convection. c)Which leads to latent heat release, and developing convective cells. The overall process is a manifestation of air-sea interaction and enhancement of convection from positive feedback mechanism.

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P-105

Development of Statistical Prediction Models for Changma Precipitation: An Ensemble

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An ensemble statistical forecast scheme with a one-month lead is developed to predict year-to-year variations of Changma rainfall over the Korean peninsula. Spring sea surface temperature (SST) anomalies over the North Atlantic, the North Pacific and the tropical Pacific Ocean have been proposed as useful predictors in a previous study. Through a forward-stepwise regression method, four additional springtime predictors are selected: the northern Indian Ocean (NIO) SST, the North Atlantic SST change (NAC), the snow cover anomaly over the Eurasian continent (EUSC), and the western North Pacific outgoing longwave radiation anomaly (WNP (OLR)).

Using these, three new prediction models are developed. A simple arithmetic ensemble mean produces much improved forecast skills compared to the original prediction model of Lee and Seo (2013).

Skill scores measured by temporal correlation and MSSS (mean square error skill score) are improved by about 9% and 17%, respectively. The GMSS (Gerrity skill score) and hit rate based on a tercile prediction validation scheme are also enhanced by about 19% and 13%, respectively. The reversed NIO, reversed WNP (OLR), and reversed NAC are all related to the enhancement of a cyclonic circulation anomaly to the south or southwest of the Korean peninsula, which induces southeasterly moisture flux into the peninsula and increasing Changma precipitation. The EUSC predictor induces an enhancement of the Okhotsk Sea high downstream and thus strengthening of Changma front.

P-106

Soil moisture-atmosphere feedback enhances temperature during 2002 heat wave event in Northeast Eurasia

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Introduction: The warm season hot weather extremes and drought become frequent and intensive in the northeast in the 2000s. This is due to the intensification of the mid-tropospheric ridge developed during the June-July-August (JJA) (Erdenebat and Sato, 2016). During the hot extreme weather events, land-atmospheric interaction plays an important rule on near-surface temperature by regulating energy flux which is dependent on soil water availability. The preceding dry soil condition can enhance surface sensible heat flux and limits evapotranspiration leading to a rapid increase of surface air temperature (SAT). However, the atmospheric response to the soil moisture (SM) conditions varies spatiotemporally. In this study the impacts of soil moisture SM on precipitation and SAT are investigated in various space and time extensions during the 2002 hot events by means of the regional model experiments with and without SM-atmosphere coupling.

Data: ERA-interim was used to examine atmospheric variables for June to August of 2002. Daily maximum SAT and precipitation at 70 meteorological stations in Mongolia is used. APHRODITE was used to evaluate model performance on precipitation variation. To evaluate the role of SM to hot extreme events, numerical experiments were conducted by WRF ver.3.6 model during hot summer (JJA) of 2002. To evaluate SM impact on extreme SAT, three set of numerical experiments were conducted; one with (coupled SM, hereafter CSM) and the other two without SM-atmosphere interaction in which the daily variations of SM in 2002 (hereafter PSM) and JJA climatology (hereafter ClimSM, 1981-2010) were prescribed. An initial SM condition of all experiments is identical utilizing multi-satellite based SM product of ESA-CCI v2.2. Through the comparison of CSM, PSM, and ClimSM runs, the impact of SM-atmosphere interaction on extreme hot events in 2002 summer was discussed.

Result: The temporal fluctuation of SM around Mongolia is larger in CSM than PSM due to active land-atmosphere interaction. The SAT in CSM experiment has a warm bias of 0.52°C for JJA mean. The root mean square error (RMSE) of daily SAT was 1.66°C. In contrast, the mean bias and RMSE for JJA are -0.14°C and 1.93°C in PSM run. The highest RMSE of SAT was in July which is 2.23°C and 1.84°C for CSM and PSM experiment, respectively. ClimSM demonstrates that area averaged (42°N-52°N, 90°E-120°E) SAT is improved by 0.8°C (JJA) and highest improvement of temperature is obtained in July (1.9°C). Realistic SM variation in PSM experiment reduces area-averaged (42°N-52°N, 90°E-120°E) RMSE for July which is the hottest month in this region. This indicates realistic SM variation regulates fluctuation of SAT by limiting surface heat flux variance. The impact of SM to SAT is not horizontally uniform in the domain. To investigate the spatial distribution of SM-SAT interaction, coupling intensity index is estimated by taking account of the difference in the SAT variance between CSM and PSM. The area averaged (42°N-52°N, 90°E-120°E) monthly-based coupling intensity index has increased -0.103, -0.115 and 0.054 for June, July, and August, respectively. The highest coupling intensity index appears in northeast China and south of the far east Russia for JJA (0.439), which suggests the impacts of SM on SAT is most intensive in this area. Similar coupling intensity index estimated between ClimSM and CSM which indicate similar coupling but weaker than PSM and CSM. Thus, wetter SM prevent high amplitude of SAT. This study notifies impact of the realistic SM variation during extreme temperature event which indicates a potential to improve the predictability of SAT.

P-107

Validation of seeding effect using multi-sensor in the cloud seeding experiments of Pyeongchang region

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Cloud seeding is to generate precipitation though development of precipitation formation process by inserting artificial nuclei into the cloud. So, it is a one of useful technology in order to secure water resource. Many previous studies reported that precipitation was enhanced by the cloud seeding for orographic clouds contained supercooled water in wintertime. In Korea, the orographic cloud seeding experiments using aircraft have been conducted in Taeback Mountains (about 800～1500 m above sea level) of the Pyeongchang region which is located approximately 20 km east of east coast of Korea during the 2008-2016 wintertime. There are generated the orographic effect by easterly wind in the Taeback Mountains because the eastern slope is steep. From 2016 season, we are conducted cloud seeding using aircraft for clouds transferred from north continental as well as clouds transferred from the east sea to the Taeback Mountains for expansion of experiment scale. If was decided to conduct experiment through weather condition monitoring, seeding path of 10 or 15 km length is designed on the upwind side to get the enhanced snowfall in the target area. A distance between the seeding path and the target area is determined by wind speed and seeding effect period. The experimental aircraft penetrate the clouds at right angles the wind direction along the seeding path for seeding, and seeding agent (AgI particles) is diffused in the clouds. For physical validation of experimental effect with observational instruments, we used data of Snow depth meter, Micro Rain Radar (MRR), Optical disdrometer (Parsivel) of ground-based observational sites built in the Pyeongchang region. Parsivel measures the size distribution and shape of precipitation particles using shading images produced by rain and snow particles passed laser beam. MRR is the vertically pointing radar that measures the reflectivity and fall velocity by altitude and yield the rainfall intensity and amount of water from it. Snow depth meter measures the height of snowfall accumulated from the ground. We can validate the experimental effect by detection of microphysical changes in cloud and increase of precipitation with these instruments. The microphysical changes of precipitation and cloud such as strengthened intensity of radar reflectivity and increased concentration of larger precipitation particles were validated in several experiments during 9 years.

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P-108

Projections of sea surface temperature over the East Asian Marginal Seas in the 21st century

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A global warming obviously leads to increasing air temperature as well as ocean temperature. Over East Asia, sea surface temperature (SST) of marginal seas has risen faster than other SST of other regions during the recent decades. It is expected to have a crucial impact on climate extreme events and sudden changes in local ecosystems. In order to reduce damages, it is necessary to establish appropriate adaptation and mitigation policies along with future comprehensive plans. Previous studies using regional climate models have shown that SST is expected to increase. However, they use a limited subset of models, and do not fully explain internal variability such as long-term oscillations. Furthermore, SST projections of marginal seas are uncertain due to internal climate variability and model errors. Thus, these approximate values may cause overconfidence.

Changes of SST under global warming are investigated using representative concentration path way 4.5 (RCP4.5) and 8.5 (RCP8.5) experiments of 26 coupled models participating in phase 5 of the Coupled Model Intercomparison Projection phase 5 (CMIP5). To improve projections of SST, probabilistic climate projections from multi-model ensembles have been conducted using both simple average and weighted average: Multi-model ensemble (MME) and Bayesian model averaging (BMA). In the view of overall changing trends of SST, we focus on area-average in the regions. Then, periods are set from historical (1951-2004) and future (2061-2100) data. Each marginal sea has unique characteristics due to bottom topography, tidal current, major ocean currents including the Kuroshio, the Tsushima Current, the East Korean Warm Current, and the Yellow Sea Warm Current, and seasonal wind fields such as monsoon flows. Therefore, marginal seas are investigated divided into three regions (Yellow Sea, South Sea, East/Japan Sea) and four seasons (DJF, MAM, JJA, SON).

SST is projected to increase about 1 to 3℃ and 2 to 5℃ under the RCP4.5 and RCP8.5 scenarios in the 90% credible interval, respectively. Projected SST in the Yellow Sea and the East/Japan Sea is larger than SST change in the South Sea, and these results are consistent with observed trends. Comparing both scenarios, SST increase over 1℃ on the RCP8.5 than on the RCP4.5. Interestingly, contrary to observational trends, SST increase more in JJA than in DJF. SST changes are projected to be stronger than experienced in the recent measurement record. A reasonable range of SST projections helps to make adaptation and mitigation policies because it represents well the uncertainties of the future.

P-109

East Asian precipitation response to the MJO and its modulation by the QBO

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The present study investigates how daily precipitation in East Asia (EA) responds to the Madden-Julian Oscillation (MJO) and how MJO-related precipitation anomalies are modulated by the Quasi-Biennial Oscillation (QBO) and El Nino-Southern Oscillation (ENSO) on interannual time scale. To obtain quantitative relationship, station-based daily precipitation datasets, provided by the Meteorological Administrations of China (CMA), Japan (JMA), and Korea (KMA), are analyzed for the period of 1979-2013 in combination with satellite observations and reanalysis datasets. A particular attention is paid for the MJO phases 2-3 and 6-7 when EA precipitation is known to vary systematically. Consistent with the recent studies, precipitation tends to increase in the southern China, southern Korea, and southern Japan (including Okinawa) during the MJO phase 2-3, but decrease during the MJO phase 6-7. This teleconnection becomes much more pronounced during the easterly phase of the QBO than its westerly phase. Their differences are up to 40% of the total MJO-related precipitation changes. However, no systematic differences in EA precipitation are observed during the El Nino and La Nina winters. This result is consistent with the recent finding that the boreal-winter MJO is significantly modulated by the QBO, and provides an additional evidence that the QBO can affect the surface climate not only in the deep tropics but also in the extratropics.

P-110

Evaluation of Land Surface Schemes in the WRF model over Korean Peninsula During 2013 Summer

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An increase in global average temperature may cause more frequent events of extreme high temperature, which exerts great impact on human society by inducing many heat-related illnesses and various economic problems. Thus, the importance of accurate prediction of such events is increasing. In this study, we evaluate sensitivity of the Weather Research and Forecast (WRF) model for different land surface schemes over the Korean Peninsula in the summer of 2013. We further investigate the WRF simulation of blocking over the Sea of Okhotsk, which affects temperature on the Korean peninsula in boreal summer, using different land surface schemes.

Key words: Extreme high temperature event, WRF, Land surface schemes, Blocking

P-111

Application of Machine Learning Techniques for Summer Monsoon Rainfall Prediction: A Case Study for Central India Region

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Abnormal weather conditions like floods, drought, heat and cold waves seriously affect the livelihood of individuals and the socio-economic growth of the country; its timely and accurate predictions have huge practical importance, which will not only save billions of dollars but also save precious human life. There have been numerous efforts in this endeavor, mainly through physically based dynamical weather prediction and statistically prediction, however many times these approaches fail to make accurate prediction, thus it is highly desirable to look for other potential approaches such as machine and deep learning, which may be more appropriate for such purposes. This work is a step forward in this direction, wherein we have applied machine learning approach for summer monsoon rainfall prediction for central India, which accounts for approximately 47% of the all India summer monsoon rainfall. This region has been experiencing considerable changes with the extreme weather conditions. The proposed study investigated the applicability of machine learning algorithms for CI region using JJAS time series data. Different statistical measures have been used to show the efficacy of the proposed algorithms.

P-112

A climatological validation of urban air temperature and electricity demand simulated by a regional climate model coupled with an urban canopy model and a building energy model in an Asian megacity

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In this study, we validated urban air temperature and electricity demand associated with anthropogenic heat (AH) by a year-round numerical simulation using a regional climate model coupled with an urban canopy model and a building energy model (RCM-UCM+BEM) in the Asian megacity, Osaka, which is the largest metropolis in Japan after Tokyo. The control simulation (CTRL), which was based on the use of central air-conditioning (AC) systems, reproduced the surface air temperatures observed in Osaka City in the summer cooling and interim seasons, but underestimated midnight to morning temperatures by over 2ºC in the winter heating season. In addition, the CTRL significantly overestimated the electricity demand in Osaka City in both the cooling and heating seasons, when the AC load was increased. These errors were likely due to the overestimation of AC use in the CTRL model because, in Japan, central AC systems are not used in business and residential areas, where individual AC units are mainly used. To prevent this overestimation, we introduced three new parameters to consider the use of partial AC systems in the model. The results of the new numerical experiment remarkably reduced the underestimation of temperature and the overestimation of electricity demand. This suggests that the RCM-UCM+BEM modified by this study is effective for not only reproducing the current status of seasonal urban air temperature and electricity demand in Osaka, but also for projecting the future situation in other mega cities.

P-113

Analysis of the outflow boundary induced heavy rainfall that occurred in the Seoul metropolitan area

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In Korea, heavy rain occurs frequently during the summer season, resulting in property and human damage every year. On August 8, 2015, heavy rainfall occurred in the Seoul metropolitan area due to an outflow boundary that formed over the Yellow Sea, and 77 mm/hr rainfall was recorded in Gwangju, Gyeonggi Province. In this study, the simulation of the WRF (Weather Research and Forecasting) numerical model was performed to understand the cause and characteristics of heavy rainfall using the Conditional Instability of the Second Kind (CISK), frontogenesis function, and convective available potential energy (CAPE) analyses, etc.

Convective cells initiated over the Shandong Peninsula and were located on the downwind side of an upper level trough. Large amounts of water vapor were supplied to the Shandong Peninsula along the edge of a high pressure, resulting from the remenouts of typhoon Soudelor. The mesoscale convective system (MCS) developed severely through the process of positive CISK feedback and moved to the Yellow Sea. Downdraft currents from the MCS formed gust fronts, which eventually grown to an arc shaped outflow boundary. The outflow boundary gradually progressed east with the movement of the MCS, pushing cold pool eastward. The warm and humid air over the Korean Peninsula further enhanced convective development through CISK. As a result, a new MCS developed rapidly over land. Because of the latent heat release due to convection and precipitation, strong potential vorticity exceeding 5 PVU was generated in the lower atmosphere in the lower atmosphere. The rapid development of MCS and the heavy rainfall occurred in the area where the CAPE value was greater than and where the frontogenesis function of 1.4 or greater coincided.

The frequency of heavy rainfall due to a mesoscale phenomena such as the outflow boundary is common during the summer time. This study shows that analyzing parameters of bulk Richardson number (BRN), CAPE, frontogenesis function and CISK are good indictors of understanding heavy rainfall characteristics due to outflow boundary.

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P-114

Prediction of the dominant intraseasonal modes over the East Asia-western North Pacific summer monsoon region

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The skillful prediction of the East Asian-western North Pacific summer monsoon (EA-WNPSM) is the most imperative, but difficult task due to the non-linearity in seasonal migration of the monsoon rainfall in summer. We have aimed to provide a physical understanding of the sources for prediction of dominant intraseasonal modes in the EA-WNPSM on interannual variability, which is represented as annual occurrences in a particular mode. The dominant intraseaonal modes (pre-Meiyu & Baiu, Changma & Meiyu, WNPSM, and monsoon gyre) are classified by the self-organizing map analysis, which is a type of artificial neural network. The selected predictors are based on the persistent and tendency signals of the sea surface temperature (SST)/2m air temperature and sea level pressure fields, which reflect the asymmetric response to the El Nino Southern Oscillation (ENSO) and the ocean and land surface anomalous conditions. For the pre-Meiyu&Baiu mode, the SST cooling tendency over the western North Pacific (WNP) causes strong meridional gradient of temperature that is a source of baroclinic instability. A major precursor for the Changma & Meiyu mode is related to the WNP subtropical high, induced by the persistent SST difference between the Indian Ocean and the western Pacific. The WNPSM mode is mostly affected by the Pacific-Japan pattern, and monsoon gyre mode is primarily associated with a persistent SST cooling over the tropical Indian Ocean by the preceding ENSO signal. Establishing physical precursors of the four intraseasonal modes, including nonlinear character, can reduce social and economic losses and play a crucial role in having implications for prediction.

P-115

Comparison of Wind Resource Characteristics in Korea According to Different Mapping Method

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Wind resource map based on TMY (Typical Meteorological Year) method in Korea with 1 km horizontal and 1 hour temporal resolution had been developed for the period from 1998 to 2009. WRF model simulation was performed to produce wind resource map for each month of TMY. A new wind resource map was also developed for 2010～2013 period using WRF model with hourly IC (Initial Condition) and BC (Boundary Condition) data from KLAPS (Korea Local Analysis and Prediction System), which is KMA's operational very short-range NWP (Numerical Weather Prediction) model with 5 km horizontal resolution, to supplement the discontinuous period of TMY. Comparison of these two wind resource maps (TMY and KLAPS wind resource maps) with KMA's ASOS data shows that bias and RMSE (Root Mean Square Error) were significantly reduced in the KLAPS wind resource map (17.9% and 10.6% for bias and RMSE, respectively).

The KLAPS wind resource map shows annual, seasonal, diurnal (daytime and nighttime) variations of wind quite reasonably, and also provides useful information for specific sites such as mean/maximum wind speeds, prevailing wind direction, and frequency of 3～25 m /s wind, which can be used for efficient management of wind farms.