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S2E Presentation

S2E-1

Cloud and precipitation properties by radar reflectivity factor and path integral attenuation from CloudSat and CALIPSO

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In order to investigate the microphysics of the clouds and precipitation, we developed algorithms for CloudSat radar using the radar reflectivity factor profile and the Path Integrated Attenuation (PIA) information derived from the surface normalized radar cross section. The PIA contains the information of cloud and precipitation microphysics. Thus it is expected that incorporation of PIA can reduce the uncertainties in the retrieval of cloud microphysics from CloudSat only algorithm and CloudSat and CALIPSO algorithm. Estimates of the PIA are carried out by using CloudSat radar and synergy use of CloudSat radar and CALIPSO lidar.

We use CloudSat data from 2B-GEOPROF (release R04) and CALIPSO lidar data from level 1B (version 3), surface wind and seas surface temperature data from AMSR-E/AMSR-2 and atmospheric data from European Center for Medium-range Weather Forecasting (ECWMF). We use the merged data sets created from the combination of CloudSat and CALIPSO where both data have the same horizontal and vertical resolutions. Here the CALIPSO data are sampled when the along track and cross-track distance between footprints of CloudSat and CALIPSO data are within 0.55 and 0.7km, respectively [Hagihara et al., 2010, 2014]. The data is called KU-merged data set. Cloud detections are performed according to the modified version of KU-mask for the merged data sets. Revised cloud detection scheme is developed and applied to CALIPSO lidar data [Katagiri et al., in preparation]. By using the revised cloud mask, underestimation of low cloud fraction is corrected in lower part of clouds and fully attenuated pixels are also identified.

Then ice and water cloud discrimination is conducted by modified version of KU-type algorithm [Yoshida et al., 2010, Kikuchi et al., under review].

The estimate of the PIA requires the clear separation of clear sky and cloudy sky condition. For the target record that contains clouds determined either by CloudSat alone or CloudSat and CALIPSO, the closest record without clouds is searched. Then the PIA is estimated by the difference between the surface normalized radar cross section for the clear sky and that for the target record with cloud. We investigate the effect of introducing CALISPO lidar information to derive the global distribution of the PIA.

We evaluate the retrieved results of ice and water microphysics by using CloudSat-only algorithms and those by CloudSat and CALIPSO algorithm where radar reflectivity from CloudSat and attenuated backscattering coefficient and depolarization ratio at 532nm are used to retrieve effective radius, ice (liquid) water content (KU-micro) [Okamoto et al., 2010, Sato and Okamoto 2011]. Finally, we develop the CloudSat-only algorithm that use profile of radar reflectivity factor and the PIA and also the CloudSat-CALIPSO algorithm with the PIA. The algorithms are applied to global CloudSat and CALIPSO data and the retrieval results are compared with the Tropical Rainfall measuring mission (TRMM) precipitation data. Monthly means and seasonal variation of global cloud and precipitation properties are investigated. Further improvements of the microphysical estimates are also discussed when Doppler information from the EarthCARE Cloud Profiling Radar become available.

S2E-2

Wind simulation over Incheon International Airport by IIA-300m model with modification of ancillary files and nesting domains

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The Unified model (UM10.4) simulation using Rose nesting suite at 300m over the Incheon International Airport (IIA) is carried out and the simulation results with single and multiple domains with input initial (IC) and lateral boundary conditions (LBC) from the Korea Meteorological Administration (KMA) operational local data assimilation and prediction systems (LDAPS) are compared with the observed automated weather stations (AWS) dataset.

The 300m nested prediction systems are built from 1.5-km LDAPS in KMA. They are downscaled with a single nesting domain to 500m and with three nesting domains to 300m resolution from the LDAPS for comparison. The model results are validated against the AWS to see the accuracy of the UM model's skill in simulating the high resolution winds over the IIA with single and multiple domains. The purpose of this research is to identify the optimum model nesting to achieve a reliable high resolution model in terms of spatial and temporal scale to predict the wind gust over the IIA for efficient aircraft operations.

The nesting suite is run with the default ancillary files created by the Central Ancillary program (CAP 9.0) as well as modified ancillary files created by modifying the land points over IIA region using a KMA ancillary editor. The UM model wind simulation is done with both ancillary files to see the improvements achieved by adding additional land points over the IIA domain. Further the Vegetation fraction from the IGBP data classified as 9 tiles in the ancillary file is replaced by the E-GIS data to see the effect on the UM model wind simulations.

Key words: KMA operational Local data assimilation and prediction system, Unified model, Incheon International Airport, 300m downscaled model, Rose Nesting Suite, Central Ancillary Program (CAP 9.0), KMA ancillary Editor, E-GIS data for vegetation fraction over Korean Peninsula.

S2E-3

Ensemble forecasts of low-level wind shear in the Jeju International Airport, Korea

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Low level wind shear around the runway is well understood to hazardous to airplane during landing and takeoff. In general, the wind shear events are usually associated with atmospheric instabilities caused by convective activity, specifically gust fronts and microbursts.

Wind forecasts are derived from operational deterministic models, and these are available to forecast the associated with wind shear, gust fronts and microbursts and provide timely warnings in an appropriate format. However, there is always a degree of uncertainty in the wind shear forecasts when they computed by deterministic Numerical Weather Prediction (NWP) models.

The recent studies present ensemble forecasting can describe the wind shear with higher accuracy than the ones by a deterministic model (Gill and Buchanan, 2014). In this study, the 13 ensemble forecasts of low level (<10,000 feet) vertical wind shear were calculated from output of the Korea Meteorological Administration’s Limited Area Ensemble Prediction System (LENS) for three wind guest events occurred at Jeju international airport at 2017. The LENS runs twice a day (00 and 12 UTC) out to 72 forecast hours with output in every 1 hour. The verification of the ensemble forecasts are provided by comparing with the ones computed by analysis field of KMA’s operational Local Data Assimilation and Prediction System (LDAPS).

S2E-4

Dual-Wavelength Radar Technique for Winter Precipitation Studies: A Case from GCPEx Field Campaign

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Radar-based snowfall estimation has generally been based on Ze-SR (Ze: reflectivity; SR: liquid equivalent snow rate) power laws of the form Ze=α(SR)β. Many studies have highlighted the large variability of α due to particle size distribution (PSD), density, and fall velocity whereas the variability in β is considerably less. The dual-wavelength radar reflectivity ratio (DWR) has been proposed to improve SR accuracy by estimating the particle size distribution parameter (median volume diameter D0) thus reducing the variability due to α. The two frequencies commonly used in dual-λ techniques are Ku and Ka band where the snow particle size-to-wavelength ratio is such as to fall in the Rayleigh region at Ku-band but in the Mie region at Ka-band. There has been limited use of dual-λ techniques for snowfall estimation, mainly using vertical-pointing ground radars or nadir pointing airborne radars but not to scanning ground-based radars as there are few such systems available.

Surface instruments such as 2D-video disdrometer (2DVD) and SVI (snow video imager) can be used to measure the PSD and fall velocity and the particle mass can be estimated via hydrodynamic methodologies. The Ku-band reflectivity which varies as particle mass squared is easily calculated. However, at Ka-band, the shape of the snow particle in addition to its mass becomes increasingly important for computation of reflectivity. The shapes of snow particles are complex (e.g., aggregates of different types of crystals) and it is time-consuming to calculate the scattering cross-sections using, for example, the discrete dipole approximation. It has been shown in several studies that the complex shape of the particle can be modelled as an equivalent spheroid (with fixed axis ratio and random orientation) with an “effective” density of 0.2 g/cc but with the spheroid volume being constrained by the mass of the complex shaped snow particle. The scattering by oblate spheroids is straight-forward using T-matrix method. As mentioned above, the particle mass can be estimated using disdrometer data and hydrodynamic methods. Thus, it is feasible to simulate the dual-wavelength reflectivity ratio (DWR) on a particle-by-particle basis.

The first and the most important step to investigate these approach we mentioned above is to examine whether the scattering computation using “effective” density agrees with the radar measurement or not. During the GCPEx (GPM Cold Season Precipitation Experiment) several heavily instrumented sites with 2DVD and SVI were available in a variety of winter precipitation events. We have selected one long-duration synoptic snow event which was well-observed by surface instruments and radars. The DWR and PSD based on particle-by-particle are computed and compare with D3R (Dual-frequency Dual-polarized Doppler Radar) measurement.

S2E-5

Study On the Multi-cell organizational Process of squall line and Meso-scale Characteristics in Beijing Area

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Introduction: Because of the location and the special topography in Beijing, disaster caused by convective thunderstorm happened in what time and places are not easily forecasted and early warning. Two samples of squall line have attracted our attention, one was on June 16th in 2014, and another was on August 7 in 2015. Although the paths and moving directions were not the same, thunderstorm cells all experienced new-borned, merged, strengthened in the local places and when the multi-cells clusters of the upstream moving into and highly organized, squall line formed quickly. In the process of two cases, swath damaging winds (more than 10.8m/s), hails disasters (the diameter over 4cm) and heavy rain (more than 70mm per hour) were observed.

Purpose: This paper attempts to analyze how the squall line formatted in the complicated multi-cells organizational processes, their different synoptic backgrounds, the meso-scale characteristics and dynamics mechanisms. And show some advanced forecast technology we used now.

Method and data: In this study, we used Sounding data, AWS (Auto Weather Station) data in great density, Doppler Radar, Temperature of Black Body with FY2E-satellite, VDRAS (Variational Doppler Radar Assimilation System) data, and ERA Interim daily-analysis data (0.125° *0.125°).

Conclusions: By analyzing the advanced observational and analysis technology, squall line could formatted in both strong and weak forces of the synoptic background in summer of Beijing. In the earlier complicated process, isolated cloud clusters generated and extincted in the plain area. New multi-cells were emerging between relatively independent deep convection thunderstorms and merged to "the old" to be strengthened, then formed the initial organizational linear convections system. The mature thunderstorm cells within the linear convection system were kind of continental convection clusters, the center more than 50 dbz vertically stretched over 12km, and the temperature of Black Body (TBB) were below -45℃. The thunderstorm cell is closely associated with a local enhancement of cold pool and then strong meso-scale frontal zone and outflow in the low levels strengthened. The interaction of the outflow among adjacent clusters, and the formatted strong convergence between the outflow and the environment flow are the main formation mechanism of the earlier evolutional linear convection system. When the upstream thunderstorms move down to the North-china plain from the northwest or northeast mountains, they rapidly merge and consolidate with the local multi-cells under favorable conditions, such as very high CAPE, large vertical wind shear mainly in the low level, upward motion area in front of the hill and so on, eventually a highly organized squall line with the bowing structure and meso-β-scale characteristics formed. And nowadays in Beijing, development on meso-scale NWP (BJ-RUC), ensemble prediction, and the integration of nowcasting and NWP model system RMAPS-IN (Rapid update Multi-scale Analysis and Prediction System-INCA in Beijing) provide advanced convective weather forecast methods in less than 12 hours.

S2E-6

Simulations of Urban Heat Island Using Unified Model in Seoul, Korea

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Urban areas have different surface characteristics such as roughness length, airflow in urban canopies, and evapotranspiration from their rural surrounds due to human factors like high population density, traffic, and high-rise buildings. The characteristics increase the sensible heat flux and reduce latent heat flux in the surface energy balance of urban areas. Therefore, the urban canopy model has been developed and applied to reflect the characteristics of urban areas in meso-scale models.

In this study, We investigate the impacts of urban land-use fraction and advection on urban heat island in Seoul Metropolitan using the UM (Unified Model) with a MORUSES (Met Office Reading Urban Surface Exchange Scheme), Simulations are performed with the urban surfaces represented (urban simulation) and with the urban surfaces replaced with grass (grass simulation) in order to calculate the urban heat island intensity. The urban heat island intensity is defined by the 1.5-m temperature difference between urban and grass simulations. The focus of our study is over the Seoul metropolitan area for heat waves that occurred from 2 to 9 August 2016. The land-use data is used by the Korea Ministry of Environment (2007).

As a result, the urban heat island intensity in the metropolitan area is up to 2.5℃ at daytime and 4.5℃ at nighttime, and it is higher at night than during the day. The magnitude of the urban heat island increases linearly with urban land-use fraction. The spatial distribution of the urban heat island intensity also shows its strength is larger downwind than upwind of the metropolitan area by advection. The high urban surface fraction in the city area and advection determine the temperature increments.

S2E-7

Effects of topography on the spatial characteristics of wind resources in Jeju Island, Korea

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We investigated the influence of topography on the spatial distribution of wind resources in Jeju Island, Korea, using computational fluid dynamics through analyzing 49 cases consisting of twelve wind directions and four wind speeds (3, 5, 13, and 25 m/s) along with a windless condition. The topography and surface roughness had effects on a wind velocity deficit by about 23-27% with four regions of severe wind speed reduction that correlated to significant parasitic volcanic cones; the wind speed decreased by 50-70% on the leeward side of these cones. The coefficients of determination (R2) between the inflow angle and terrain slope angle were higher in the north-south direction than in the east-west direction. Flow distortion by north-south inflow was detected up to 240 m above ground level. The distribution of critical slope and recirculation area was the most frequent in wind directions of 180° and 30°-60°, respectively. Our comparison of numerical simulation results and ground-based LiDAR observations showed that the former tended to the topographic effect on wind speed reduction in the north-eastern part of Jeju Island.

S2E-8

Fog characteristics over the region of Pyeongchang 2018 Olympic and Paralympic Winter Games

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As a major part of the International Collaborative Experiments for Pyeongchang 2018 Olympic and Paralympic winter games (ICE-POP 2018) project, the visibility data from Daegwallyeong Weather Office (DGW) and the Pyeongchang Olympic competition venues such as Yongpyong Alpine Centre (YPC), Bokwang Snow Park (BSP), Ski Jumping Centre (SJC), and Jeongseon Alpine Centre (JSC) are analyzed to identify the general fog characteristics in terms of occurrence and duration. The 36-year visibility data observed at DGW are considered to investigate the climatological features of fog over the Olympic region. The visibility observed by the four independent sensors over YPC, a primary alpine skiing competition venue of the Olympic, are also investigated during the four winter seasons from December, 2013 to March, 2017 for understanding fog characteristics over the complex terrain. Fogs occurring at DGW generally begin at dawn before sunrise, and then dissipate 2-3 hours after the sunrise mainly due to the radiative effect. During the months of the Olympic and Paralympic Winter Games, i.e., February and March, the mean fog occurrence frequencies are 17% and 23%, and the mean fog durations are 4.7 and 3.2 hours, respectively. The fog occurrence frequencies on the YPC slope in winter are 20%, 15%, 10% and 5% at the start line, middle 1 point, middle 2 point and finish line, generally with high frequency in the early morning and at night. Particularly in February, the fog occurrence frequency at the start line, however, is 20% at 9-11 Local Standard Time (LST) and 14-18 LST, which must be considered for scheduling the alpine skiing competition games at YPC. It is clearly revealed that the fog phenomena over the Olympic area have very fine spatiotemporal variability. Another alpine skiing competition venue, JSC, seems to have more frequent fog occurrence during the daytime compared to the YPC slope, which informs the necessity of more cautious competition plans at JSC. The fog occurrence and duration over BSP and SJC, however, are negligible for scheduling and managing the competition games there. Based on the general features of fog occurrence and duration over YPC, the four major phenomenal fog types are classified using the meteorological data observed by the four independent sensors on the slope. Four fog types commonly occurring over YPC in winter are dense fog over the whole slope, dense fog at the start line, light fog over the whole slope, and light fog at the start line. According to case studies, it is also revealed that strong moistening and cooling prompt dense fog, while relatively weak moistening and cooling result in relatively light fog before the fog onset. Slow wind speed is necessary for fog to cover the whole slope of YPC. The four phenomenal types of fog are attributed to the orographic lifting of moist air in conjunction with radiative cooling and also advection that is primarily caused by an occasional synoptic distribution of pressure field that induces the moist air inflow around the Korean Peninsula in winter time.