ACM 2017

ASIAN CONFERENCE ON METEOROLOGY 2017 (ACM2017)

S2C Presentation

S2C-1

Applying a coupled atmosphere-hydrology model for streamflow prediction over the Korean Peninsula

Yoon-Jin Lim (National Institute of Meteorological Sciences)
Young Ryu (National Institute of Meteorological Sciences)
Hyun-Suk Kang (National Institute of Meteorological Sciences)

This study attempts to investigate the use of a high resolution hydrological model to simulate streamflow over various basins in Korea. Here, an experimental 36-h lead-time streamflow forecasting methodology that combines the operational numerical weather prediction(NWP) model data in Korea with the physically based, spatially distributed Weather Research and Forecasting (WRF-Hydro) model is described and applied to upstream basin area in Korea in order to explore its utility. In this study, the WRF-Hydro with 150m horizontal grid spacing has been applied for assessing impact of fully coupled atmospheric-hydrological modeling on several hydrometeorological variables in Korea and the used meteorological forcing are from Local Data Assimilation and Prediction System(LDAPS) provided by the Korea Meteorological Administration(KMA), has spatial resolution of 1.5 km and 36-h lead time are at 1-h time intervals. Prior to performing coupled land-atmosphere simulations, the stand-alone hydrological model ("uncoupled" WRF-Hydro) was calibrated using observed meteorological forcing and streamflow data, the parameters controlling the infiltration capacity excess from precipitation and channel roughness data depending on stream order were optimized. Overall, the simulation results from the WRF-Hdyro with optimized parameters demonstrate the potential utility of a atmosphere-hydrology coupled system for forecasting hydrological component such as streamflow over the Korean Peninsula.

S2C-2

Predictability of NUIST earth system model and impact of stochastic parameterization over East Asian Monsoon

Young-Min Yang (University of Hawaii / Nanjing University of Information Science and Technology)
Bin Wang (University of Hawai'i at Mānoa / Nanjing University of Information Science and Technology)

The third version of the Nanjing University of Information Science and Technology Earth System Model (NESM v3.0) is developed aiming to provide a numerical modeling platform for cross-disciplinary earth system studies, project future Erath's climate and environment changes and simulate past climate changes, as well conduct subseasonal-to-seasonal prediction. The NESMv3.0 is based on NESMv1.0 with upgraded atmospheric and land surface models, improved physical parameterizations and conservation of coupling variables, as well as increased models' resolution. In this paper, we describe the model's basic features and major improvements compared with NESMv1.0, examine the ENSO and East Asian Monsoon (EAM). The result shows that the model captures observed ENSO variance, phase-locking and periodicity. The model also reproduces not only large-scale climatology and ENSO-monsoon relationship but also onset and seasonal evolution of monsoon reasonably well. The 30yr hind-cast of ENSO and precipitation using NESM were conducted to estimate their predictability. The result showed that NESM has a good predictability on ENSO but a limited for EAM. To improve EAM, we implemented stochastic methods on convective parameterization. It is show that the stochastic parameterizations enhanced simulated EAM. NO significant change was for ENSO simulation. Possible reason and processes were discussed in this study.

S2C-3

Cloud Microphysics Parameterization in a Shallow Cumulus Cloud Simulated by a Lagrangian Cloud Model

Donggun Oh (Yonsei University)
Yign Noh (Yonsei University)
Fabian Hoffmann (Leibniz Universität Hannover)
Siegfried Raasch (Leibniz Universität Hannover)

Lagrangian cloud model (LCM) is a fundamentally new approach of cloud simulation, in which the flow field is simulated by large eddy simulation and droplets are treated as Lagrangian particles undergoing cloud microphysics. For this purpose the concept of a superdroplet, which represents a large number of real droplets with the same radius is introduced, and the novel algorithm of the collision process, in which the collisional growth of each Lagrangian droplet is calculated based on the droplet size spectrum within a grid, similar to the spectral bin model (SBM), is created. LCM has many advantages over the existing Eulerian models, including SBM, as it simulates the condensational growth of droplets, the initiation of precipitation, and the turbulent diffusion of droplets within a cloud, more naturally by following each Lagrangian droplet. Furthermore, LCM enables us to investigate raindrop formation and examine the parameterization of cloud microphysics directly by tracking the history of individual Lagrangian droplets. Analysis of the variation of the background physical conditions following Lagrangian droplets that grow from cloud droplets to raindrops in a shallow cumulus cloud reveals how and under which condition raindrops are formed, and thus clarifying the respective roles of drop size distribution broadening by entrainment and by mixing, and by turbulence induced collision enhancement.

LCM also provides information how autoconversion and accretion appear and evolve within a cloud, which constitute critical parts in cloud microphysics parameterization. The calculation of autoconversion and accretion, based on the critical radius 25 m, from the simulation of a shallow cumulus cloud, corresponding to the RICO experiment, is carried out. It is found that the conversion of cloud droplets to raindrops occurs initially by autoconversion near the cloud top, but it becomes dominated by accretion in the cloud core in the later stage. In particular the calculation of autoconversion reproduces successfully for the first time the Kessler-type parameterization, which assumes the critical cloud water mixing ratio to trigger autoconversion. Sensitivities of autoconversion and accretion to various other factors are also investigated. For example, autoconversion is found to increase with decreasing aerosol concentration, increasing cloud age, and increasing turbulence intensity.

Based on these results, the parameterizations of autoconversion and accretion, such as Kessler (1969), Tripoli and Cotton (1980), Beheng (1994), and Khairoutdonov and Kogan (2000), are examined. Results are consistent with previous works based on the analysis of observation and SBM results in general, and the parameterization by Tripoli and Cotton (1980) is found to show a better agreement by adjusting empirical parameters.

S2C-4

Comparison of Multi-model Microphysics Schemes Using Radar Observations

Ki-Hong Min (Kyungpook National University)
Swapan Mallick (CIMMS/OU)
Jungho Bae (Kyungpook National University)

The quantitative precipitation forecasting (QPF) capability of the radar variational assimilation method using two numerical weather prediction (NWP) models is investigated over the Korean Peninsula. The two NWP models considered in this study are the UKMO Unified Model (UM) and the Weather Research and Forecasting (WRF) model with double-moment 6-class microphysics scheme (WDM6). We calculated radar equivalent reflectivity using the Korean Meteorological Administration (KMA) Local Data Analysis and Prediction System (LDAPS) based on UM and compared with radar observations in Korea. To compare the cloud microphysics scheme in simulating precipitation, three types of experiments are performed using UM and WRF model and with 3D-Var assimilation method. Comparisons of the 24-hr accumulated rainfall with Automatic Weather Station (AWS) data, contoured frequency by altitude diagram (CFAD), time-height cross sections, and vertical profiles of hydrometeors are used to evaluate the schemes and understand model predictability. Two heavy rainfall cases during the monsoon season of 2016 and one convective case in 2014 are selected for comparison with the 24-hr accumulated precipitation from AWS and CMORPH data.

S2C-5

MODIS- CALIPSO-CloudSat synergy for the analysis of ice cloud microphysics

Hiroki Kitagata (Kyushu University)
Hajime Okamoto (Kyushu University)
Kaori Sato (Kyushu University)
Shuichiro Katagiri (Kyushu University)
Hiroshi Ishimoto (Meteorological Research Institute, JMA)

We developed CALIPSO-MODIS-CloudSat algorithm to retrieve ice microphysics. The split window method was originally developed by Inoue [1987] and used the combination of channels around 10μ m to infer ice optical thickness and effective radius. The technique has been widely accepted because of the applicability to optically thin ice clouds. CloudSat and CALIPSO satellites were launched in 28 April 2006 and have been operational since June 2006. Though the original life time were 22 months for CloudSat and three years in orbit for CALIPSO, respectively, they are still providing data after 10 years. They are flying NASA afternoon constellation of satellites, called A-trains so that CloudSat radar, CALIPSO lidar and MODIS on Aqua are able to see the same place at almost the same time [Stephens et al., 2002]. These A-train data sets offered a unique opportunity to revisit the split window method. In this study, we use MODIS on Aqua, CALIPSO lidar and CloudSat radar. The conventional split window method used radiances at 8.70, 11.03 and 12.02μ m by MODIS (hereafter MODIS-only method). In the approach, cloud top height was retrieved by the radiance at 11.03μ m and geometrical thickness of the clouds should be assumed. These cloud boundary information, vertical inhomogeneity of cloud microphysics and cloud particle shape and its orientation are the essential sources of uncertainties in the retrieved cloud microphysics. In the MODIS-CALIPSO-CloudSat synergy approach, cloud boundaries were determined by using modified version of KU-mask algorithm where cloud occurrences were determined by CloudSat and CALIPSO masks [Hagihara et al., 2010, 2014, Katagiri et al., in preparation]. Ice clouds were discriminated by the modified version of KU-type algorithm [Yoshida et al., 2010]. Ice cloud microphysics were first determined by the MODIS-only method and compared with the results from MODIS-CALIPSO-CloudSat synergy approach. Retrieved optical thickness of ice clouds obtained by the three-sensor algorithm was about 60% larger than that by the MODIS-only method. Retrieved effective radius obtained by the three-sensor algorithm was about 30% smaller than that by the MODIS-only method. The differences attributed to the difference in cloud top and bottom heights between the two methods.

Then we compared the retrieval results by the three sensor methods and those by the CloudSat-CALIPSO algorithm (KU-micro) [Okamoto et al., 2010, Sato and Okamoto 2011]. The optical thickness and effective radius from the split window methods based on the three sensors agreed better than the conventional one. We also developed another version of three- sensor method to retrieve vertical profile of cloud microphysics. The effect of addition of MODIS information to the CloudSat-CALIPSO algorithm will be discussed. A joint JAXA-ESA satellite, the Earth Clouds, Aerosol and radiation Explorer (EarthCARE) is scheduled for launch in FY 2018. It will carry four instruments; cloud profiling radar with Doppler function at 94GHz (CPR), high spectral resolution lidar at 355nm (ATLID), multi-spectral imager (MSI) and broad band radiometer (BBR). Since the combination of CPR, ATLID and MSI corresponds to the extended version of CloudSat, CALIPSO and MODIS, the developed algorithms in the study can be adopted as standard algorithms for EarthCARE analysis.

S2C-6

Track Pattern Classification of Extratropical Cyclones over the Korean Peninsula: Spatial Distribution, Climatology and Long-term Trend

Hyeong-Oh Cho (Seoul National University)
Doo-Sun Park (Korea Environment Institute)
Seok-Woo Son (Seoul National University)

The extratropical cyclone (ETC) is one of the most important weather phenomena in mid-latitudes. It has significant roles on the economy, agriculture and daily life because of the accompanying precipitation, wind and cloud distribution. In this regard, understanding properties of the ETCs is necessary for both improvement in weather prediction skills and reduction of socioeconomic damages. The ETCs have huge influences on East Asia and its effects have a large regional inhomogeneity. For these reasons, previous studies noted that characteristics and trajectories of the ETCs in East Asia. However, statistical approach about the detailed classification for track pattern of the ETCs over the Korean peninsula had not been sufficiently established. Thus, this study sorted types of the ETCs trajectories that were passing through Korean peninsula and then investigated its spatial distribution, climatic features and temporal variations.

The objective classification method used in this study is the fuzzy c-means clustering method. This method is widely used in clustering analysis that could be applied to spatial distribution such as tracks of the ETCs. To identify and track the ETCs, a Lagrangian cyclone-tracking algorithm was applied to relative vorticity at 850 hPa for period 1979-2014. The relative vorticity was filtered to wave numbers from 5 to 42 in order to reduce the influence of large-scale circulation and small-scale eddies for considering only synoptic-scale low pressure systems. Environmental variables such as wind and geopotential height field were explored to analyze relationship between the ETCs and large-scale circulation patterns.

A total of 3886 detected ETCs tracks passing through the Korean peninsula were classified into three clusters: 1) 1076 ETCs passing southern part of Korean Peninsula, 2) 1458 ETCs passing northern part of Korean Peninsula, 3) 1352 ETCs passing center of Korean Peninsula. The ETCs over the Korean peninsula have two main genesis regions: downstream of Altai-Sayan mountain range and Tibetan plateau. The ETCs in cluster 1 mainly originated from lee side of Tibetan plateau, most of the ETCs in cluster 2 were generated over the backside of Altai-Sayan region and the ETCs in cluster 3 were developed from both regions. The ETCs showed the maximum of seasonal frequency at spring in all clusters, and the minimum frequency of the ETCs exhibited at autumn in cluster 1, while the ETCs in cluster 2 and 3 appeared the minimum of frequency at summer.

In aspects of long-term trend, only the ETCs in cluster 1 at springtime showed significant negative trend in annual frequency. The main cause of decreasing trend in frequency was reduction in genesis of the ETCs on the major formation region for cluster 1 (on the east side of Tibetan plateau). To figure out the cause of decrease in cyclogenesis, linear regression on environmental variables was performed. As a result, anticyclonic circulation was increased in south China, and this intensified anomalous high-pressure system may possibly reduce genesis of the ETCs. Further studies to reveal the relationship between track patterns of the ETCs and its impact will be examined.

Key words: extratropical cyclone, fuzzy c-means clustering, Korean peninsula