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S2D Presentation

S2D-1

Application of CNN for detection of overshooting tops using Himawari-8 images

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Overshooting tops (OT) are one of the most common atmospheric phenomena in tropical regions. OT is a cloud formed like a dome shape on the top of a storm. The occurrence of OTs can lead to various severe weather conditions on the ground including cloud-to-ground lightning, strong winds, and heavy rainfall, which may have an influence on flight and ground operations. During strong updrafts of OTs, tropospheric water vapor or various gases can be transported into the stratosphere, then affecting the balance of atmospheric constituents and even climate changes. Various approaches have been developed to detect OTs using satellite data. The most well-known methods are the WV-IRW BTD and IRW-texture methods. The WV-IRW BTD method detects OTs by utilizing the difference between water vapor and infrared channel. It is a method to infer OT positions with the presence of water vapor generated by OT on cloud tops. Without the dependence on water vapor channel, the IRW-texture method was proposed which uses infrared images only for the detection of OTs. It is based on the characteristics of OT which is a cluster of pixels with relatively lower temperatures than the surroundings. However, it has a limitation that several fixed thresholds are used in the processing steps of the method, which makes it not effective for OT detection in various sizes and temperature conditions. More recently, a new OT detection method using pattern recognition along with several supplemental rating evaluations and logistic regression was proposed. As the method was elaborately designed, it shows better performances than the others. However, it is quite time-consuming due to complex and multi-layer analysis. OT detection methods using various machine learning techniques were also developed by producing OT results with both binary and probability. It was found that the machine learning-based OT detection method outperforms the other methods. However, humans find OTs by examining spatially the relationship between pixels in images, which is more intuitive, accurate, and generalizable regardless of seasons and OT characteristics such as its sizes and temperatures. In this study, we develop a CNN-based automatic OT detection system to mimic the 'human being's detection' rather than identifying individual pixels. To develop a model, firstly input data specific to a CNN-based model are constructed. An optimal CNN-based OT detection model was developed based on the input data. Then, images of different dates were validated on the developed model to evaluate the significance of the model, and the CNN model was performed for unseen (i.e. new) OT data. The CNN-based model achieved significant improvement of accuracy for detecting OTs.

S2D-2

Variously Microphysical Characteristics Associated with Orographically Modified Winds in South Korea

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This study uses high temporal and spatial resolution data to investigate the characteristics of microphysics over complex terrain in Pyeongchang area. Multiple radars and automatic weather system are used to derive these data through Wind Synthesis System using Doppler Measurements (WISSDOM). The objective of this study is to figure out the possible relations between orographiclly modified winds and microphysics during the passage of a low pressure system (LPs) from southwestern to southeastern side of Korea peninsula in winter. The results indicated that intensive precipitation concentrated at both southwestern and northeastern side of topography in period I but at northeastern side during period II. The southerly flow was blocked on southwestern branches of topography and deflected to become southwesterly flow in the period I. During the period II, the environmental winds changed from easterly to northeasterly offshore the Gangneung city. The easterly winds have locally decelerated and deflected along the coast near the topography. This modified flow caused different characteristics of microphysics in these two periods. For the period I, most iced particles were produced on southwestern slope (windward slope) and drifted by the winds to fall down on the crest or lee side. For the period II, the origin of iced particle have stronger relations with updraft, higher concentrations of small iced particles may produced by deposition process. These two different microphysics will dominate possibly the intensity and distributions of precipitations over topography in South Korea.

S2D-3

Relationship of backscatter color ratio, lidar ratio and depolarization ratio of ice, water and aerosols and the wavelength-dependence

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We analyzed ice and water cloud properties and aerosol properties by using High Spectral Resolution Lidar (HSRL) at 532nm, Raman lidar at 355nm and Mie type lidar at 1064nm. The lidar systems were developed by National Institutes for Environmental Studies (NIES) in Tsukuba, Japan. The lidar system provides three attenuated backscattering coefficients at 355nm, 532nm and 1064nm, two extinction coefficient and two depolarization ratios at 355nm and 532nm. There are some advantages in HSRL and Raman compared with the Mie-type lidar; Backscattering coefficient and extinction coefficient can be directly obtained by High Spectral Resolution Lidar (HSRL) and Raman Lidar and assumption of ratio of extinction coefficient to backscattering coefficient (lidar ratio) is not needed. In addition, multi-wavelength signature of backscattering coefficient, lidar ratio and depolarization ratio of clouds and aerosol can be investigated by the system. It is therefore expected that detail analysis of HSRL and Raman lidar observations can lead to new insights to our understanding of clouds and aerosol.
We first develop algorithms to discriminate clouds and aerosol for the three wavelengths. Then ice and water clouds partition are carried out.

Analyses of ice clouds showed lidar ratio and depolarization ratio at 532nm ranged from 10 to 40 (mostly between 10-20) and 40 to 60%, respectively. Relationship between lidar ratio and depolarization ratio are examined. There is no correlation between the two values, contrary to the previous findings (Reichardt et al., 2002), though the relationship can be used to discriminate ice clouds from other species such as dust. Then we derive the backscatter color ratio defined as ratio of backscattering coefficient at 532nm to that at 355nm and depolarization color ratio defined as depolarization ratio at 532nm divided by that at 355nm. The former values are from 2 to 2.8 and the latter ones are from 1.2 to 2.0. That is, the backscattering coefficient of ice particles at longer wavelengths are larger than that at shorter wavelengths. Wavelength dependence of lidar ratio and depolarization ratio might depend on the shape and orientation of ice particles.

Then analysis of water clouds showed that there is no wavelength dependence of backscatter color ratio as expected from the Mie theory. Depolarization ratio at 355nm is slightly smaller than that at 532nm. Finally aerosol properties are analyzed. Depolarization ratio are smaller than 10% at 355nm and 532nm indicating no dust particles. Lidar ratio ranges from 20 to 100 at 532nm and 10 to 120 at 355nm, respectively. We will report the comparisons between the observed properties and theoretical predicted ones, based on the physical optics and discrete dipole approximation for non-spherical particles. The Japan-Europe joint satellite program EarthCARE is scheduled to be launched in FY 2018 with a High Spectral Resolution Lidar observation with a wavelength of 355 nm (ATLID), Doppler cloud radar at 94GHz (CPR), multispectral imager (MSI) and broad band radiometer (BBR). The algorithms and findings in the studies can be adopted to the analysis of EarthCARE/ATLID.

S2D-4

Improvement of Rainfall Measurements by Using Dual Tipping-Bucket Rain Gauge

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This study presents an improvement in the accuracy of rainfall measurements by using a new type of rain gauge, a dual tipping bucket rain gauge (DTBG). The DTBG is composed of two tipping bucket rain gauges, the resolutions of which are 0.1mm and 0.5mm, respectively. The study shows that the measurement error due to water splash-out is substantially reduced by using the DTBG. The present work demonstrates that the DTBG greatly improves the rainfall measurements by catching the rainfall splash-out. The demonstration was made by the intercomparisons of rainfall measurement for eight rainfall events. The intercomparison results suggest that for the accumulated rainfall amount greater than 20mm, the rain measurements by the DTBG were more accurate, compared to those by single TB rain gauges, irrespective of their resolutions. The rainfall measurements by the DTBG were compared with those by Pluvio2 (weighing rain gauge) to assess the performance of the DTBG for eight events of rainfall measurements. Among the events, the DTBG showed better performance for five events, compared to the Pluvio2. Our detailed analyses suggest that the accuracy of the DTBG was found to be almost the same as the Pluvio2. Since the DTBG can be used for field measurement at low cost of installation and maintenance, it has a potential to be used as a practical rain gauge at the automatic weather stations for operational purpose.

S2D-5

Development of Automatic Cloud Observation System (ACOS) Estimating the Amount and Base Height of Cloud

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The automatic cloud observation system (ACOS) acquiring the sky of celestial sphere and estimating the amount and base height of cloud has been developed. The cloud amount estimation of ACOS gives good correlation coefficeint (R^2=0.91) with the eye measruement at Daejeon for the 3 hours interval during 3 months in May to July in 2017. For case studies, the captured images show the number of faults for the satellite-based, eye measured, and ACOS cloud amounts as follows: 10, 8, and 3, respectively. Most of ACOS faults happen when near sun rise and set occationally, because then the blue color image make deluding all the sky as clear. The cloud base height obtained by the dual ACOS gives better agreement with that of ceilometer, comparing with the eye measurment, which is due to the rule of eye measurement for the cloud base height. These results suggest that the ACOS can be a better alternative operation instrument at least for measuring the cloud amount, though the cloud base height estimated by ACOS will be further improved.

S2D-6

Correction of solar radiation effect on temperature measurement by radiosondes using dual thermistors

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The measurement of essential climate variables (ECVs) in the upper air mostly relies on radiosondes equipped with a group of sensors flying up to about 35 km in altitude. Among ECVs, the measurement of air temperature is warm-biased by solar irradiation during daytime. However, the correction of warm-biased temperature is still challenging since it is affected by other environmental characteristics in upper air such as low-temperature, low-pressure, and ventilation. For example, according to the recent WMO intercomparison of high quality radiosonde systems, corrected temperatures are deviated by up to 1.7 K at about 32 km in altitude depending on radiosonde manufacturers. However, the deviation in the nighttime at the same altitude is 0.8 K which is smaller than that in the daytime. This suggests that a more accurate compensation process for solar irradiation effects is required, especially in a traceable manner to the International System of Units (SI).

Here, the combined effect of low-temperature and low-pressure as well as the ventilation on the air temperature measurement under irradiation is studied for the correction of warm-biased temperature of radiosondes. Dual thermistors with different emissivity are used as temperature sensors for the measurement of solar irradiance using the temperature difference. A vacuum chamber-based system inside a freezer and a wind tunnel is used for mimicking the upper air environment. The temperature difference of dual thermistors is utilized in order to calculate the irradiance through the establishment of the relationship among the temperature difference and other environmental parameters at varied irradiance, ventilation speed, temperature, and pressure that range from 0 W•m^{-2} to 1500 W•m^{-2}, from 0 m•s^{-1} to 10 m•s^{-1}, from -80℃ to 25℃, and from 10 hPa to 1000 hPa, respectively. It is found that the temperature difference between dual thermistors is increased as the irradiance is increased, ventilation speed is decreased, temperature is lowered, or pressure is lowered. The observed behavior is explained using heat transfer equations and organized into a single formula. After the combined relationship among parameters is established, the temperature difference between thermistors is solely used to calculate the irradiance with no pyranometer. The calculated irradiance is then used for the correction of the warm-biased temperature of thermistors. The corrected value is also increased as the irradiance is increased, ventilation speed is decreased, temperature is lowered, or pressure is lowered. Finally, the unifying correction formula is obtained using the ground-based facility and applied to radiosonde field tests. Uncertainty of corrected temperature will be presented. The dual thermistor-based technique with ground-based calibration facilities can provide the traceability to the International System of Units (SI) in the measurement of irradiance and temperature in upper air.

S2D-7

Refinement of cloud mask and cloud particle type algorithms for synergistic use of space-borne lidar and cloud radar data

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In this paper, we discuss the improvements in our cloud mask and cloud particle type algorithms for the Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard CALIPSO distributed as the KU-mask [Hagihara et al., 2010]. Comparison among the global mean cloud fraction derived from the NASA Langley standard algorithm, GOCCP and the KU-mask and type algorithms has reported inconsistencies in the ice and water cloud fractions according to different assumption adopted in the aerosol-cloud discrimination, spatial resolution, and the treatment of fully attenuated lidar pixels [Cesana et al., 2016]. Concerning the KU-mask, smaller cloud fraction was reported in low-level cloud compared to other schemes. This was considered to be attributed in part to the fact that fully attenuated pixels were not identified in the old KU-mask product, which affected the result statistically, and in part by the treatment of strongly attenuated pixels. The KU-mask is based on a threshold method of the attenuated total backscattering coefficient ß at the original CALIOP resolution [Hagihara et al., 2010]. In this study, we first evaluate KU-mask and KU type by using Multiple-field-of-view multiple-scattering polarization lidar (MFMSPL). The MFMPL is the first ground-based lidar that can detect depolarization ratio affected by the similar degree of multiple scattering in the space-borne lidar signals. We found the underestimation of low-level cloud fraction. In the refined KU-mask scheme, remaining noise and its standard deviation are estimated in stratosphere. In addition, different treatment of lidar signals from cloud top layer and from the layers below is performed, based on the analyses of multiple scattering in lidar signals in optically thick part of the clouds. Finally fully attenuated pixels is identified by introducing the surface reflectance in a refined KU-mask algorithm. Cloud particle type algorithm (KU-type) introduced in Yoshida et al., [2010] is also refined. KU type discriminates warm water, super cooled water, randomly oriented ice, horizontally oriented ice and fully attenuated pixels from CALIOP observables. Evaluation of KU-type by the MFMSPL showed possible misclassification of water as ice for optically thick water clouds. Treatment of cloud particle type below cloud top is different in the refined scheme. Global analyses of ice and water cloud fraction are conducted by the refined KU-type algorithm. Water cloud fraction by the new KU-type scheme increases compared with those by the old KU-type. There is no significant changes in ice cloud fraction between the new and old KU-type algorithms. We will also report the change in results for CloudSat and CALIPSO merged cloud mask and type due to the refinements described above. A joint JAXA-ESA satellite, EarthCARE (The Earth Clouds, Aerosol and radiation Explorer), is scheduled for launch in FY 2018, which is equipped with 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). We also discuss about the further modifications of refined KU-mask and type algorithms in order to analyze EarthCARE data.