Taipei Severe Weather and Extreme Precipitation

Extreme Climate | Severe Weather | Thunder Storm | Extreme Precipitation

2019 Taipei SWEP Workshop

24 – 26 April 2019

RCEC Lecture Hall, Academia Sinica

中央研究院 環境變遷研究大樓

Table of Contents

Program

Day 1 April 24th (Wednesday)

<table>
<tr><th>Time</th><th>Program</th><th>Oral presentation title / Speaker (affiliation)</th><th>Session Chair</th></tr>
<tr><td>08:30-09:00</td><td colspan="3">Registration</td></tr>
<tr><td>09:00-09:20</td><td colspan="3">Opening Remark

Academician Pao K. Wang (王寶貫 院士)
Director, Research Center for Environmental Changes,
Academia Sinica, Taiwan</td></tr>
<tr><td>09:20-10:00</td><td>Keynote (I)</td><td>Satellite observations of gravity waves, generated by convective storms into the upper atmosphere
Martin Setvák
Czech Hydrometeorological Institute, Czech</td><td rowspan="3">Yu-Chieng Liou (廖宇慶)
National Central University, Taiwan</td></tr>
<tr><td>10:00-10:25</td><td>D1-01</td><td>Storm top dynamics - a review
Pao K. Wang (王寶貫)
Research Center for Environmental Changes,
Academia Sinica, Taiwan</td></tr>
<tr><td>10:25-10:50</td><td>D1-02</td><td>Diagnosis of the Dynamic Efficiency of Latent Heat Release and the Rapid Intensification of Supertyphoon Haiyan (2013)
Hung-Chi Kuo (郭鴻基)
National Taiwan University, Taiwan</td></tr>
<tr><td>10:50-11:10</td><td colspan="3">Group Photo / Break</td></tr>
<tr><td>11:10-11:35</td><td>D1-03</td><td>Heavy Rain Events in Taipei, An Observational Study
Ben J.-D. Jou (周仲島)
National Taiwan University, Taiwan</td><td rowspan="2">Ming-Jen Yang (楊明仁)
National Taiwan University, Taiwan</td></tr>
<tr><td>11:35-12:00</td><td>D1-04</td><td>Development of variational-based data assimilation systems and their applications in analyzing heavy rainfall processes
Yu-Chieng Liou (廖宇慶)
National Central University, Taiwan</td></tr>
<tr><td>12:00-13:30</td><td colspan="3">Lunch</td></tr>
</table>

Time	Program	Oral presentation title / Speaker (affiliation)	Session Chair
13:30-13:55	D1-05	*Taiwan-area Heavy rain Observation and Prediction Experiment (TAHOPE)* **Ming-Jen Yang (楊明仁)** National Taiwan University, Taiwan	**Shih-Hao Su (蘇世顥)** Chinese Culture University, Taiwan
13:55-14:20	D1-06	*High-Resolution Time-Lagged Ensemble Quantitative Precipitation Forecasts for Typhoons in Taiwan using the Cloud-Resolving Storm Simulator* **Chung-Chieh Wang (王重傑)** National Taiwan Normal University, Taiwan	
14:20-14:45	D1-07	*Steps towards using all-sky radiances for severe weather forecasting* **Jeffrey Steward** University of California, Los Angeles, USA	
14:45-15:10	**Break / Poster**		
15:10-15:35	D1-08	*Developing an extreme rainfall warning system with the machine learning method* **Shih-Hao Su (蘇世顥)** Chinese Culture University, Taiwan	**Jeffrey Steward** University of California, Los Angeles, USA
15:35-16:00	D1-09	*Upper-air Radiosonde and "Storm Tracker" Observations in TASSE 2018* **Hungjui Yu (尤虹叡)** National Taiwan University, Taiwan	
16:00-16:25	D1-10	*Shor-Duration Heavy Rainfall Quantitative Precipitation Nowcasting - Toward the Big Ensemble and Radar Data Mining Approach* **Treng-Shi Huang (黃椿喜)** Weather Forecast Center, Central Weather Bureau, Taiwan	
16:25-16:50	D1-11	*Essential factors for organization of afternoon thunderstorm in the Taipei basin: A case study on 30 Jun 2018* **Satoki Tsujino (辻野智紀)** National Taiwan University, Taiwan	
18:00	**Banquet (Invitation only)**		

Day 2 April 25th (Thursday)

Time	Program	Oral presentation title / Speaker (affiliation)	Session Chair
08:30-09:00	**Registration**		
09:00-09:40	**Keynote (II)**	*Compositing visible, near-infrared, and infrared wavelengths for meteorological feature identification* **Jordan Gerth** University of Wisconsin-Madison/SSEC, USA	**Kao-Shen Chung (鍾高陞)** National Central University, Taiwan
09:40-10:05	D2-01	*Diurnal Variation of Mesoscale Circulation and Precipitation During Mei-Yu Season over Taiwan and Surrounding Area* **Pay-Liam Lin (林沛練)** National Central University, Taiwan	
10:05-10:30	D2-02	*Dynamical Downscaling Simulation and Future Projection of Extreme Precipitation Activities in Taiwan during the Mei-Yu Seasons* **Wan-Ru Huang (黃婉如)** National Taiwan Normal University, Taiwan	
10:30-11:00	**Break / Poster**		
11:00-11:25	D2-03	*Challenges and improvements in short-term precipitation prediction based on the WRF-LETKF radar data assimilation system* **Shu-Chih Yang (楊舒芝)** National Central University, Taiwan	**Wan-Ru Huang (黃婉如)** National Taiwan Normal University, Taiwan
11:25-11:50	D2-04	*Evaluation the performance of very short-term forecast by dual-polarimetric radar observations* **Kao-Shen Chung (鍾高陞)** National Central University, Taiwan	
11:50-12:15	D2-05	*Assimilating radar observed and retrieved variables to improve the model convective scale rainfall forecast : OSSE and a real case study* **Yu-Ting Cheng (鄭羽廷)** National Central University, Taiwan	
12:15-13:30	**Lunch**		

Time	Program	Oral presentation title / Speaker (affiliation)	Session Chair
13:30-13:55	D2-06	*Sudden Intensification of Typhoon Hato (2017)* **Iam-Fei Pun (潘任飛)** National Central University, Taiwan	**Balaji Kumar Seela** National Central University, Taiwan
13:55-14:20	D2-07	*Deep Convective Cloud Properties of Tropical Cyclone (TC) Meranti (2016): A Case Study of TC Intensity Change* **Jason Pajimola Punay** National Central University, Taiwan	
14:20-14:45	D2-08	*Microphysical Characteristics of Different seasons and type of Precipitation over Northern Taiwan* **Meng-Tze Lee (李孟澤)** National Central University, Taiwan	
14:45-15:10	**Break / Poster**		
15:10-15:35	D2-09	*Raindrop Size Distribution Characteristics of Summer and Winter Season Rainfall Over North Taiwan* **Balaji Kumar Seela** National Central University, Taiwan	**Iam-Fei Pun (潘任飛)** National Central University, Taiwan
15:35-16:00	D2-10	*A sensitivity study of the ventilation effect and the hail's shape parameter on the structures of developing supercells* **Yen-Liang Chou (周彥良)** Research Center for Environmental Changes, Academia Sinica, Taiwan	
16:00-16:25	D2-11	*Remote Triggering Effect of a Tropical Cyclone in the Bay of Bengal on a Heavy Rainfall Event in Subtropical East Asia* **Sho Arakane (荒金匠)** Research Center for Environmental Changes, Academia Sinica, Taiwan	
16:25-16:50	D2-12	*Characteristics of the Marine Boundary Layer Jet over the South China Sea during the Early Summer Rainy Season of Taiwan* **Chuan-Chi Tu (涂絹琪)** National Central University, Taiwan	

Day 3 April 26th (Friday)

Time	Program	Oral presentation title / Speaker (affiliation)	Session Chair
08:30-09:00	**Registration**		
09:00-09:25	D3-01	*Tropical cyclone structures as depicted by WWLLN data – Convection asymmetry* **Shu-Jeng Lin (林書正)** Chinese Culture University, Taiwan	**Shu-Jeng Lin (林書正)** Chinese Culture University, Taiwan
09:25-09:50	D3-02	*Characteristics of Deep Convections and Associated Dynamic Conditions from Cloudsat Over the South China Sea and Maritime Continent* **Chian-Yi Liu (劉千義)** National Central University, Taiwan	
09:50-10:15	D3-03	*The Numerical Study of Severe Precipitation Induced by Local Circulation in Taiwan* **Jou-Ping Hou (侯昭平)** Chung Cheng Institute of Technology, National Defense University, Taiwan	
10:15-10:35	**Break**		
10:35-11:00	D3-04	*Mechanisms of Orographically Enhanced Precipitation Associated with Typhoon Meari (2011) over Mt. Da-Tun* **Shaun-Ping Chen (陳渲屏)** National Taiwan University, Taiwan	**Jou-Ping Hou (侯昭平)** Chung Cheng Institute of Technology, National Defense University, Taiwan
11:00-11:25	D3-05	*Reconstructed typhoon series 1644-1911 and implications of general atmospheric-oceanic circulation* **Kuan-Hui Elaine Lin (林冠慧)** Research Center for Environmental Changes, Academia Sinica, Taiwan	
11:25-13:30	**Discussion & Working Lunch**		

Posters

No.	Presenter (affiliation)	Poster Title
P01	**Tzu-Chin Tsai (蔡子衿)** National Taiwan University, Taiwan	*Evaluating the role of physical parameterizations on the simulations of afternoon thunderstorm precipitation with a multi-moment bulkwater microphysics scheme in the WRF mode*
P02	**Yian Chen** National Central University, Taiwan	*Verification of multiple-Doppler-radar derived vertical velocity using profiler data*
P03	**Yi-Chen Liu (劉宜真)** National Central University, Taiwan	*Cloud Top Features of Atmospheric Convections from Himawari-8*
P04	**Yu-Chen Lin** National Central University, Taiwan	*Investigation of the Cloud and Precipitation Properties of Deep Convective Core from CloudSat Observation*
P05	**Hua Hsu** National Taiwan University, Taiwan	*Afternoon Thunderstorm in Taipei Basin during Summer*
P06	**Chi-June Jung** National Taiwan University, Taiwan	*A Case Study of Afternoon Thunderstorm in Taipei City: Characteristics of Rainfall Structure*
P07	**Jason Pajimola Punay** National Central University, Taiwan	*Deep Convective Cloud Properties of Tropical Cyclone (TC) Meranti (2016): A Case Study of TC Intensity Change*
P08	**Chih-Heng Wang (王志亨)** National Central University, Taiwan	*Developing Space-borne Quantitative Precipitation Estimation - Preliminary result on Typhoon Cases*

Keynote I

Satellite observations of gravity waves, generated by convective storms into the upper atmosphere

Martin Setvák

Czech Hydrometeorological Institute
Praha, Czech

Abstract: By the end of 1980's, convective storms have been identified as a source of concentric gravity waves (CGW), occasionally affecting atmospheric nightglow layers. Since then, various methods of gravity wave detection in the upper stratosphere and mesosphere have significantly evolved and improved, including satellite observations. Among the satellite methods, nocturnal low-light observations by Day/Night Band (DNB) of the Suomi-NPP and NOAA-20 (JPSS-1) satellites, and observations by hyperspectral sounders aboard some of the low-Earth orbit satellites belong among the most recent ones. This work focuses on DNB-based observations of CGW in nightglow emissions near the mesopause and early statistics of their global occurrence, and for several cases documents their detection in AIRS/Aqua and IASI/Metop hyperspectral data.

Keywords: convective storms; concentric gravity waves; nightglow, DNB

D1-01

Storm top dynamics - a review

Pao K. Wang

Research Center for Environmental Changes, Academia Sinica
Taipei, Taiwan

Abstract: Severe storms pose a serious threat to human society and reliable forecast of them will help mitigate the potential damages by them. They also play an important role in the global climate process. Satellite data can provide the widest coverage and continuous information of storm activities for forecasters and researchers but these data have to be interpreted correctly to render them useful. In this presentation, I will examine the physical and dynamical processes responsible for the main visible and IR features at storm tops as seen by meteorological satellites using mainly cloud dynamical model simulations but also some supporting ground-based and aircraft observations. The implications of severe storms on global atmospheric processes will be discussed and some suggestions for future research will be offered.

Keywords: storm dynamics; satellite observations; gravity waves

D1-02

Diagnosis of the Dynamic Efficiency of Latent Heat Release and the Rapid Intensification of Supertyphoon Haiyan (2013)

Hung-Chi Kuo

National Taiwan Normal University
Taipei, Taiwan

Abstract: We use a cloud-resolving model with full physics to simulate the rapid intensification (RI) of Supertyphoon Haiyan (2013). We derived energy conversion rate from latent heating to kinetic energy (named as energy efficiency) based on a gradient-wind balanced and axisymmetric vortex. The dynamic efficiency rapidly increased during the RI period. The increase indicates that enhancement of eyewall convection is closely linked to increasing of baroclinicity in the inner side of the eyewall in RI. The increase of the baroclinicity induces more efficient energy conversion from latent heating to kinetic energy in the eyewall. Our model results also highlight the cross-scale interaction of unbalanced dynamics. The PV mixing, boundary layer inflow, convective PV tower, and subsidence in the eye region that also contributes greatly to the RI dynamics.

Keywords: rapid intensification; energy efficiency

D1-03

Heavy Rain Events in Taipei, An Observational Study

Ben J.-D. Jou

National Taiwan University
Taipei, Taiwan

Abstract: Convective activity around metropolitan Taipei City is greatly affected by the Snow Mountain Range (SMR), especially in the warm season with weak synoptic conditions. Pronounced convective activity is frequently observed around the mountain range and causes severe flash floods in the metropolitan of Taipei. The formation mechanisms of a daytime and a nighttime Taipei heavy rain-flash flood event are investigated in this study. The results show the daytime heavy rain event was triggered by severe air-mass afternoon thunderstorms with complex structure. Storm initiation was closely related to insolation-produced sea breeze and upslope flows. The short-duration torrential heavy rain occurred during the merger of convective cells. This pronounced cell merging is associated with enhanced low-level convergence induced by the sea breeze and prior storm-produced outflows.

On the other hand, the heavy rain at night highlighted the importance of locally enhanced baroclinicity due to intrusion of cold air. Elevated convection triggered by the lifting of warmer air above the shallow cold surface was responsible for the flash flood in the basin. The convective cells in the basin intensified while merging with the eastward propagating convection that had formed over the coastal region.

For the daytime heavy rain case, air mass thunderstorm signatures are identified by polarimetric parameters, i.e., the presence of Zdr and Kdp columns indicating deep and strong convective updrafts and producing upward transport of liquid water above the melting layer. Nevertheless, for the heavy rain at night, no Zdr or Kdp columns are identified. It is noted the large accumulated rainfall amounts are produced by the continuous passage of convection lines. Large Zdr or Kdp are only observed at low-level indicating the dominant warm rain process.

In addition to the weak synoptic-forced systems, two heavy rain events with strong forcing are also briefly introduction. One is with Meiyu front and pronounced low-level jet and the other is with tropical depression (TD) in southeast ocean and approaching cold front system from northwest. All the cases brought extreme precipitation.

Keywords: heavy rain; flash flood; afternoon thunderstorm; cell merge; cold air intrusion; polarimetric signatures

D1-04

Development of variational-based data assimilation systems and their applications in analyzing heavy rainfall processes

Yu-Chieng Liou

National Central University
Taoyuan, Taiwan

Abstract: WISSDOM (Wind Synthesis System using Doppler Measurements) is a 3DVar-based multiple-Doppler radar wind analysis system. It is able to recover the winds along/near radar baseline and over complex terrain. The retrieved wind from WISSDOM can be readily applied for vorticity budget analysis. In this study, WISSDOM is further improved so that it can optimally synergize the information obtained not only from Doppler radar, but also from mesoscale model outputs, satellite, profiler, radiosonde, and surface station. A terrain-permitting thermodynamic retrieval scheme (TPTRS) is also designed to utilize the WISSDOM-synthesized wind fields to construct the three-dimensional pressure and temperature fields over complex topography.

IBM_VDARS (Immersed Boundary Method__Variational Doppler Radar Analysis System) is a 4DVar-based radar data assimilation system with terrain-resolving capability. Further improvement is also conducted allowing this system to assimilate surface wind, temperature, and vapor observations.

Both WISSDOM and IBM_VDARS are applied to generate high spatiotemporal resolution of meteorological fields, which are utilized to analyze heavy rainfall processes, and identify key factors leading to the extreme precipitation.

Keywords: radar; data assimilation; heavy rainfall; topography

D1-05

Taiwan-area Heavy rain Observation and Prediction Experiment (TAHOPE)

Ming-Jen Yang

National Taiwan University
Taipei, Taiwan

Abstract: Taiwan-Area Heavy rain Observation and Prediction Experiment" (TAHOPE) will be conducted from August 2019 to July 2022 to study Mei-Yu fronts, mesoscale convective systems (MCSs), and landfalling typhoons near Taiwan. During May to August 2020, TAHOPE will join the PRECIP2020 (USA) and TPARC-II (Japan) to conduct the joint field experiment for severe weather (Mei-yu fronts and typhoons) in the vicinity of Taiwan. The main themes of TAHOPE project range from large-scale environmental influence, mesoscale convective systems as well as microscale cloud physics processes, under the special topography of Taiwan Island with steep terrain. Through the joint network of intense observations, real-time or near real-time data assimilation and prediction will be conducted using advanced atmospheric models.

In order to accomplish this large internationall joint observation and prediction experiments, National Taiwan University takes a role in integrating the available domestic observation instruments and invites interested scientists to jointly submit an integrated three-year research proposal (from 1 August 2019 to 31 July 2022) to the Ministry of Science and Technology (MOST), Taiwan. The U.S. Partners have submitted requests to the National Science Foundation (NSF) and National Oceanic and Atmodpheric Administration (NOAA) on several instruments (P3-aircraft, S-PolKa radar, and CSU SEA-Pol radar) to combine with CWB's operational observation facilities (radars and radiosondes), and the atmospheric measurements (C-Pol radar, wind profiler, dropsonde, and aerosonde) of National Applied Research Laboratory (NARL) to perform intense observation experiment during 25 May to 31 August 2020; meanwhile, the evaluation of data impact on the assimilation and prediction from Taiwan's satellite (FORMOSAT-7) GPS RO and reflectometry measurements will be

carried out during the field experiment. The U.S. partners include project principal investigators, Dr. Michael Bell (CSU professor) and many renowned scientists (Profs. Yi-Leng Chen, Yuh-Lang Lin, Kristen Rasmussen, Rob Rogers, Fuqing Zhang, and others). On Taiwan side, the TAHOPE Project Office led by Prof. Ming-Jen Yang, has been set up and integrated 10 subprojects related to the observation and data assimilation. In addition, other 9 subprojects related to the modeling and routine-data assimilation/analysis work are integrated into the TAHPEX (Taiwan-Area Heavy-rainfall Prediction Experiment) project (which is led by Prof. Chung-Chieh Wang); the two TAHOPE and TAHPEX integrated projects are supporting each other through observation data exchange and resource sharing. Each subproject will be coordinated by the TAHOPE Project Office with the help of two project consultants (Prof. Ben J.-D. Jou at NTU and Dr. Bill Y.-H. Kuo at NCAR). The Scientific Advisory Committee consisting of senior scientists in Taiwan and USA will also provide valuable comments and suggestions on the proposed scientific goals and experimental design of the joint project."

Keywords: mesoscale convective system; landfalling typhoon; microphysical processes; intense observation experiment

D1-06

High-Resolution Time-Lagged Ensemble Quantitative Precipitation Forecasts for Typhoons in Taiwan using the Cloud-Resolving Storm Simulator

Chung-Chieh Wang

National Taiwan Normal University
Taipei, Taiwan

Abstract: In this study, the performance of time-lagged ensemble quantitative precipitation forecasts (QPFs) for typhoons in Taiwan, with a cloud-resolving grid spacing of 2.5 km, a large domain of 1860 km x 1360 km, and an extended range of 8 days, is discussed. Evaluations for 27 typhoons in 2012-2016 shows that the system produced a decent QPF at the longest range at day 5.4, providing much extended lead time, especially for slow-moving storms that pose higher threats. In addition, since forecast uncertainty (reflected in spread) reduces with lead time, the system is well suited to provide a wide range of rainfall scenarios in Taiwan at longer lead times, and also accurate QPFs at shorter lead times when the predicted tracks converge (toward the best track) as the uncertainty reduces. This strategy fits well our conventional wisdom to “hope for the best, but prepare for the worst” when facing natural hazards. Overall, the system compares favorably in usefulness to a typical 24-member ensemble (5-km grid size, 3-day forecasts) using comparable computational resources.

With more details, the time-lagged ensemble QPF results for several typhoons that are among the most hazardous in recent years: Morakot (2009), Saola (2012), Soulik (2013), and Soudelor (2015) are also presented and discussed. The overall results show the following. (1) The quality and accuracy of the QPFs in Taiwan are, as expected, mainly dictated by track errors, but a high-quality QPF can again be produced at a lead-time much longer than 3 days when the track error is small. (2) At short ranges within 2-3 days, both the lagged tracks and QPFs are often very consistent and accurate, and the derived probability for heavy rainfall can also be very high and accurate at the correct regions in Taiwan, quite frequently over the mountain slopes.

Keywords: typhoon; quantitative precipitation forecast; lagged ensemble; cloud-resolving model; Taiwan

D1-07

Steps towards using all-sky radiances for severe weather forecasting

Jeffrey Steward

University of California, Los Angeles
Los Angeles, CA, USA

Abstract: All-sky (including clear and cloudy) satellite radiances, both infrared and microwave, are an incredibly rich source of information regarding severe weather. However, there are a wide range of issues that prevent effective use of these radiances for severe weather forecasting. High temporal and spatial resolution IR radiances are sensitive to humidity and temperature in the clear, but in cloudy regions they can typically only see cloud tops for optically thick clouds. Microwave radiances can see through clouds to directly find precipitation but are highly sensitive to hydrometeor size and shape assumptions. This talk will present new technology and methodologies, including deconvolution and a statistical operator, to assimilate both microwave and infrared radiances.

Keywords: infrared microwave; satellite; radiances; all-sky clouds

D1-08

Developing an extreme rainfall warning system with the machine learning method

Shih-Hao Su

Chinese Cultural University
Taipei, Taiwan

Abstract: The extreme rainfall (ER) event is one of the major natural disasters and has a very high impact on the livelihood and economy in Taiwan. ER events are usually accompanied by very complex cross-scale interaction process and caused some uncertainties of the Quantitative Precipitation Estimations (QPEs) /Quantitative Precipitation Forecasts (QPFs). In this study, we used machine learning (ML) technic as a new approach of multi-time scales QPEs and QPFs. We based on the experience of extreme rainfall studies to select meteorological factors that contribute to the severe rainfall events. We used the localized real-time surface observations, multi-time integrated radar reflectivity and gridded numerical forecasting output as model input data to develop an artificial intelligence based extreme rainfall warning system in Taipei Metropolitan Area. The preliminary results show the ML-based QPE/QPF has a similar capability with traditional radar-QPE/QPF methods. Compared to the current ensemble reginal model warning system, there is also the same or more predictive ability for heavy rainfall events. The ML QPE/QPF has good performance on non-extreme rainfall events but has a larger error for estimation of extreme rainfall amount. It may be limited by sample frequency and need to use some other approach to improve the QPE/QPF of rare events.

Keywords: extreme rainfall; machine learning; weather classification; warning system

D1-09

Upper-air Radiosonde and "Storm Tracker" Observations in TASSE 2018

Hungjui Yu

National Taiwan University
Taipei, Taiwan

Abstract: Taipei Summer Storm Experiment (TASSE) had been conducted during the summers of 2016, 2017 and 2018, aiming to gain further understanding of the short-term, extremely heavy afternoon thunderstorms and the induced flash floods occurring in the Taipei metropolitan area (the Taipei basin). By the deployment of multiple observational platforms including three upper-air radiosonde observational sites and one mobile radar site (the X-band Taiwan Experimental Atmospheric Mobile Radar, TEAM-R) around Taipei city, the experiment had acquired the unprecedented datasets of the atmosphere over the basin with temporal resolution up to 1-hourly during the daytime.

During TASSE 2018, the experimental upper-air observational instrument newly-developed by the group at NTU, a.k.a. the Storm Tracker was utilized to gain the details of the land-sea breeze around the basin. The Storm Tracker was launched at the three upper-air radiosonde observational sites every hour during the daytime, in particular at Banqiao site, the Storm Tracker was attached to the Vaisala RS41 radiosonde for intercomparison and data correction. In total, over 500 Storm Trackers and 114 RS41 radiosondes were launched in the TASSE 2018.

This study presents the preliminary results of the upper-air observations in TASSE 2018 and the data reliability and applicability of the Storm Tracker.

Keywords: TASSE; upper-air radiosonde; Storm Tracker

D1-10

Shor-Duration Heavy Rainfall Quantitative Precipitation Nowcasting - Toward the Big Ensemble and Radar Data Mining Approach

Treng-Shi Huang, Shin-Husan Yeh, Kuo-Chen Lu, Jing-Shan Hong

Weather Forecast Center, Central Weather Bureau
Taipei, Taiwan

Abstract: Weather in Taiwan is dominated by the Asia-Australia monsoon system, under the influence of which a strong southwesterly enters the South China Sea in May and in June, resulting in the “Plum Rain” known as “Meiyu” in Taiwan. Lately in July, the area from south China sea to the east of Philippine is dominated by the monsoon depression, a breeding sea area of typhoon. Taiwan, however, is usually on the path of mean typhoon movement once it genesis. During the warm season form May to November, torrential rainfall accompanied with Meiyu front, Typhoon, southwesterly flow or thunderstorm is threaten people’s wellbeing and safety in Taiwan.

This situation is getting worse because the global warming raised more frequent extreme weather worldwide, especially for the short-duration heavy rainfall. Last year on 23 August, a tropical depression quickly formed and moved to western Taiwan, bringing long-duration heavy rainfall which continued for days with peak intensity up to 100 mm h-1 for hours and flooding many areas in southwestern Taiwan. One more year ago, an major Meiyu front on 2 June 2017 also brings long-duration and short-duration heavy rainfall on 2017 Meiyu season. It is , however, the great challenge for the quantitative short-duration heavy rainfall forecast for any operation center. In order to better forecasting the short-duration heavy rainfall system, the Center Weather Bureau (CWB) focus more on the 0 to 6 hours extended nowcasting recently. By integrating the radar, rain gauge and ensemble forecast system, we develop a rapid updated quantitative precipitation nowcasting (QPN) based on the “Radar Data Mining”. The term “Radar data mining” is indicated to distinguish with the

“Radar data assimilation”. Rather than the traditional method to assimilated the radar observation into the model initial condition, this concept is to mining those already existing ensemble forecasting by using the radar observation. By applied this concept into the major weather events for torrential rainfall in recent year. The skill score based on the radar data mining is proved to be better than any other operated numerical or extrapolated technique for 0 to 3 hour QPN in Taiwan.

Keywords: QPF; QPN; Radar data mining

D1-11

Essential factors for organization of afternoon thunderstorm in the Taipei basin: A case study on 30 Jun 2018

Satoki Tsujino

National Taiwan University
Taipei, Taiwan

Abstract: Afternoon thunderstorms in the Taipei basin often cause severe meteorological disasters in the metropolitan area. Full understanding of essential factors for formation and organization of the afternoon thunderstorms is important for accurate weather prediction using numerical models. In this study, numerical simulations in two realistic situations, which are thunderstorm (TS) and no-thunderstorm (no-TS) cases, are performed to clarify the essential factors using a non-hydrostatic atmosphere model with full physics. The simulation in TS succeeds to capture formation and development of the realistic precipitation clouds in the Taipei basin. The two simulations are verified by hourly atmospheric soundings in a field campaign, and reasonably capture thermal structure and evolution of sea-breeze circulation in the Taipei basin. In TS, the simulated moisture field is high in the troposphere, the environmental flow is weak, and sea-breeze layer is gradually developing in the afternoon. On the other hand, a thick and dry layer lies in 3-km to 10-km heights, there is clear southeasterly wind above 3-km height, and the sea-breeze layer is suppressed below 1-km height in no-TS.

To isolate the essential factors, additional simulations are performed with actual soundings in the TS and no-TS cases under no environmental flow (No-Env) and southeasterly flow (Env). Although the thermal structure in the TS case is significantly different from that in the no-TS case, amount and horizontal distribution of rainfall in TS resemble the realistic simulation in no-TS under No-Env. On the other hand, rainfall amount under Env is clearly reduced, compared with that under No-Env in no-TS. The simulations clarify that (1) depth of afternoon sea-breeze circulation in the Taipei basin and (2) moisture and weak large-scale flow in the middle troposphere are essential factors for the formation and organization of the afternoon thunderstorm. In particular, the large-scale flow plays several important roles in reduction of the afternoon rainfalls due to ventilation in the middle troposphere.

Keywords: meso-scale convective system; sea-breeze circulation; numerical model

Keynote II

Compositing visible, near-infrared, and infrared wavelengths for meteorological feature identification

Jordan Gerth

University of Wisconsin-Madison/SSEC
Madison, WI, USA

Abstract: Meteorologists were quick to realize the capabilities of the new-generation geostationary weather satellites for rapidly imaging (up to 30 seconds) and capturing amazing detail (down to 0.5 km) of evolving weather phenomena. But there is still more value to unlock in the visible, near-infrared, and infrared wavelength spectral bands from the similar United States' Advanced Baseline Imager (ABI), Japan's Advanced Himawari Imager (AHI), and Korea's Advanced Meteorological Imager (AMI).

With this additional data, the challenge is determining how meteorologists can ascertain information about the atmosphere and land surfaces through the combination of multiple spectral bands. In understanding the environmental scenarios for which certain spectral bands are useful, multi-spectral satellite imagery and the application of spatial filters provide an opportunity to easily and quickly identify spatial and spectral patterns that represent atmospheric or surface features and confirm conceptual models of phenomena and their development. Red-Green-Blue (RGB) tri-band composite imagery has been a popular technique for collocating and colorizing multiple bands to the benefit of the savvy analyst. There are several other color spaces that may provide more color contrast than RGB composite imagery of atmospheric features. Examples from the AHI over the western Pacific Ocean will be shown to highlight the benefits.

This presentation will further discuss how imagery and products from the new era of weather satellites can inform our understanding of the interactions and properties of features in the atmosphere, focusing on the some of the new and lesser-known applications on the horizon.

D2-01

Diurnal Variation of Mesoscale Circulation and Precipitation During Mei-Yu Season over Taiwan and Surrounding Area

Pay-Liam Lin

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Abstract: This study divides the Mei-Yu season of 2008-2012 into pre-Mei-Yu (5/15-5/31), mid-Mei-Yu (6/1-6/15), post-Mei-Yu (6/16-6/30) and use WRF model to simulate the regional climate in order to discuss the seasonal changes of the circulation and precipitation. Under the seasonal change condition, the wind field, precipitation, cloud amount of Taiwan and southeastern China have significant diurnal change. Taiwan Strait area is under the effect of the land-sea breezes on both Taiwan and southeastern China sides. At night, the land breezes from both sides are significant III so the low-level convergence is evident, causing a higher chance of precipitation within the Taiwan Strait than during daytime. In the afternoon, due to the impacts of sea breezes-upslope flow and orographic lifting, the rainfall occurs inland or in the mountain areas, whereas, occurs at shore at night over Taiwan. During the mid Mei-Yu season, the southwesterly flow strengthens. The orographically induced barrier jet usually occurs on the northwest coast of Taiwan, and it would converge with the prevailing winds producing precipitation in some cases. If the southwesterly flow strengthens, more prevailing airflow can pass across over the mountains, causing significant thermal effects at lee-side of the east of Taiwan. In the afternoon, prevailing flows over southwestern Taiwan is prone to passing through the Central Mountain Range (CMR) when the terrain is heated. Thus, leeside low and subsidence effects are more significant. The rainfall distribution over Taiwan will be different with the transformation of large-scale circulation. To sum up, during Mei-Yu season, the interaction among fronts, orographic effect, prevailing winds and land-sea breezes are complicate which also affect the diurnal cycle of circulation and precipitation over Taiwan and the surrounding area.

Keywords: land sea breeze; precipitation; terrain effect

D2-02

Dynamical Downscaling Simulation and Future Projection of Extreme Precipitation Activities in Taiwan during the Mei-Yu Seasons

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Abstract: By using the Weather Research and Forecasting (denoted as WRF) model driven by two super-high-resolution global models, High Resolution Atmospheric Model (denoted as HiRAM) and Meteorological Research Institute Atmospheric General Circulation Model (denoted as MRI), this study investigates the dynamical downscaling simulation and projection of extreme precipitation activities (including intensity and frequency) in Taiwan during the Mei-Yu seasons (May and June). The analyses focus on two time period simulations: the present-day (1979–2003, historical run) and the future (2075–2099, RCP8.5 scenario). For the present-day simulation, our results show that the bias of HiRAM and MRI in simulating the extreme precipitation activities over Taiwan can be reduced after dynamical downscaling by using the WRF model. For the future projections, both the dynamical downscaling models (i.e., HiRAM-WRF and MRI-WRF) project that extreme precipitation will become more frequent and more intense over western Taiwan but less frequent and less intense over eastern Taiwan. The east-west contrast in the projected changes in extreme precipitation in Taiwan are found to be a local response to the enhancement of southwesterly monsoonal flow over the coastal regions of South China, which leads to an increase in water vapor convergence over the windward side (i.e., western Taiwan) and a decrease in water vapor convergence over the leeward side (i.e., eastern Taiwan). Further examinations of the significance of the projected changes in extreme precipitation that affect the agriculture regions of Taiwan show that the southwestern agriculture regions will be affected by extreme precipitation events more frequently and more intensely than the other subregions. This finding highlights the importance of examining regional differences in the projected changes in extreme

precipitation over the complex terrain of East Asia.

Keywords: dynamical downscaling; future projection; Meiyu

D2-03

Challenges and improvements in short-term precipitation prediction based on the WRF-LETKF radar data assimilation system

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Abstract: The Local Ensemble Transform Kalman Filter radar data assimilation system coupled with the Weather Research and Forecasting model (WLRAS) has been established for the purpose of improving the very short-term precipitation prediction. The applications of the WLRAS have been very successful to cases like typhoon or meiyu-related convective storms. Nevertheless, the performance of the WLRAS can be limited by sampling errors due to the use of limited ensemble sizes. Based on a heavy rainfall event on 16 June 2008, sampling errors are sensitive to the relationship between the simulated observations and model variables, the intensity of the reflectivity and the characteristics of the radar radial wind measurement. The use of a large enough ensemble size and large localization scale can better represent the moisture field and provide effective vertical adjustment, and both are crucial in improving the heavy rainfall prediction.

With a heavy rainfall event that occurred in Taiwan on 10 June 2012, the performance of WLRAS can be improved by additionally assimilating the ground-based GPS-zenith total delay (ZTD), which can provide the direct moisture information. Assimilating the ZTD data can overcome the mispredictions originally shown in the precipitation prediction involved with radar data only. Consequently, assimilating both the ZTD and radar data gives the best predictions of the location and intensity of the heavy rainfall. However, the impact of ZTD data needs to be optimized with a broader horizontal localization scale than the convective scale used for radar data assimilation in order to consider the network density of the ZTD observations and the horizontal scale of the moisture transport by the southwesterly flow in this case.

Keywords: heavy rainfall prediction; ensemble kalman filter; data assimilation; radar data

D2-04

Evaluation the performance of very short-term forecast by dual-polarimetric radar observations

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Abstract: To evaluate the performance of numerical weather prediction and identify the model errors at storm scale, observation operators for dual-polarimetric radar data have been applied in this study. First, the WRF-LETKF system is used to assimilate radar reflectivity and Doppler wind to obtain the optimal analysis on Jun 14th during the SoWMEX IOP8 in 2008. By using Polarimetric Radar Data Simulator, model outputs have been converted and compared to the NCAR S-Pol dual-Pol parameters. By examining Contour Frequency Altitude Diagrams (CFADs) of ZH, ZDR and KDP, results show that the improvements can be up to 3 hour forecast lead time. On the other hand, the improvement of Z_DR and K_DP could be limited without assimilating dual-polarimetric data.

Keywords: Dual-Polarimetric radar data; model validation

D2-05

Assimilating radar observed and retrieved variables to improve the model convective scale rainfall forecast: OSSE and a real case study

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Abstract: This research discusses rainfall forecast improvement using radar data. Through OSSE tests the importance of vapor is identified. By assimilating three-dimensional meteorological fields obtained from multiple-Doppler radar wind synthesis and thermodynamic retrieval into WRF, the improvement of the rainfall forecast for a heavy precipitation event occurring on 14 June, 2008 in southern Taiwan is investigated.

The process of understanding mesoscale weather systems requires high-resolution three-dimensional thermodynamic fields. This study uses OSSE to test the sensitivity of different meteorological variables to forecasting and the feasibility of water vapor adjustment. The real case selects the case of heavy rainfall in southern Taiwan on June 14, 2008, and use the multiple Doppler radar wind field synthesis method (Wind Synthesis System using Doppler Measurement, WISSDOM), thermodynamic retrieval and temperature/moisture adjustment to retrieve the three dimensional wind, pressure, temperature and water vapor fields above complex terrain, and assimilate into WRF to explore whether retrieved variables could improve the short-term rainfall forecast by using different statistical parameters to verify the ability.

The OSSE results show that if the TRUE (moist, strong convection) meteorological variables (three dimensional winds, pressure, temperature, water vapor mixing ratio and rain water mixing ratio) are completely replaced into the CTRL (dry, non-convection), the results of the forecast for three hours show that variables replacement significantly improves the CTRL, develops convection and let rainfall

distribution similar to the TRUE. By comparison, the result without replacing the water vapor field are the worst, the convection dissipates within fifteen minutes, but if using the water vapor adjustment, the results are obviously improved. The above validate the correct water vapor field is extremely important in the forecast. The real case results show that assimilating two radar volume scan, the rainfall forecast is closer to the observed which compared with the non-assimilating forecast. The ETS (Equitable Threat Score) also exceeded 0.3 after 60 minutes forecast.

Keyword: thermal retrieval

D2-06

Sudden Intensification of Typhoon Hato (2017)

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Abstract: Typhoon Hato (2017) experienced a sudden intensification to a category-3 intense typhoon just before making landfall on Macau on 23 August 2017. The unexpected strong wind speed of 51.4 m s-1 severely damaged the city in an unprecedented level, causing 10 people died and over US$ 1.5 billion estimated economic loss. It was the worst typhoon to hit Macau in the past 50 years. Based on satellite observations, atmospheric reanalyses and model simulations, we found that the anomalous thermal condition of coast water is mainly responsible for Hato's sudden intensification, with the atmosphere also providing a favorable environment. If this result is indeed the general case, it would be a very worrisome situation to coastal areas, such as the southern coast of China. In those areas, the landfalling typhoons may likely keep intensifying until the last minute, increasing the challenge in intensity prediction and posing greater threat to the people living in those areas.

Keywords: typhoon; rapid intensification; landfall

D2-07

Deep Convective Cloud Properties of Tropical Cyclone (TC) Meranti (2016): A Case Study of TC Intensity Change

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Abstract: Convective clouds in the inner core of a tropical cyclone (TC) are unique as within them are extremely deep, intense and rotational updrafts with relatively weak downdrafts. This study investigates the deep convective clouds' (DCCs) properties in the inner core of TC Meranti with respect to intensity changes. Infrared brightness temperature (IR BT) is used to identify DCCs and their properties such as cloud ice water path (CIWP), effective radius (CER) and optical thickness (COT). The study reveals that in the inner core, Meranti's intensification shifts the DCC's CIWP and COT preferences to higher values and increases the homogeneity of CER distribution. Additionally, rapid intensification and slowly weakening lowered the CER preference values, which coincide with associated wide and heavy precipitation. This behavior of CER in the inner core suggests a previously unknown connection between the precipitation and TC intensification and weakening.

Keywords: tropical cyclone; deep convective cloud; Meranti

D2-08

Microphysical Characteristics of Different seasons and type of Precipitation over Northern Taiwan

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Abstract: Extremes of rainfall during the transition season often cause flooding and mudslides. Accurate rainfall prediction can help to alleviate the effects of such rainfall events. In the present work, long-term (10 years) raindrop size distribution (RSD) measurements from Joss Waldvogel Disdrometer (JWD) installed at National Central University (NCU, 24°58'6"N 121°11'27"E), Taiwan and vertical profile of radar reflectivity were used to analyze the variations in gamma parameters of six seasons (winter, spring, mei-yu, summer, typhoon, and autumn) and types of precipitation. The normalized gamma distribution of RSD revealed that the highest mean Dm (Mass-Weighted Average Diameter) values were in summer, whereas the highest mean log10Nw (normalized intercept parameter) values were in winter. Vertical structures detected in radar reflectivity profiles dominate the results of seasonal RSD. Furthermore, most of the rainfall rate falling at less than 20 mm h-1 occurs in Northern Taiwan. In this study, we used radar reflectivity to differentiate between convective and stratiform systems. It was revealed that the mean Dm values are higher in convective systems, whereas the mean log10Nw values are higher in stratiform systems. The structure of RSD in stratiform systems remains constant in all seasons; however, convection is similar to maritime type. Contoured Frequency by Altitude Diagrams (CFADs) revealed that vertical structures dominate RSD in various types of precipitation.

Keywords: DSD; Microphysics; QPE

D2-09

Raindrop Size Distribution Characteristics of Summer and Winter Season Rainfall Over North Taiwan

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Abstract: Raindrop size distribution (RSD) characteristics of summer and winter seasons over north Taiwan are analyzed by using long-term (~12 years) raindrop spectra from Joss-Waldvogel disdrometer located at National Central University (24°580N, 121°100E), Taiwan. Along with the disdrometer data, radar reflectivity mosaic from six ground-based radars, Tropical Rainfall Measuring Mission, Moderate Resolution Imaging Spectroradiometer, and ERA-Interim data sets are used to establish the dynamical and microphysical characteristics of summer and winter rainfall. Significant differences in raindrop spectra of summer and winter rainfall are noticed. Winter rainfall has a higher concentration of small drops and a lower concentration of midsize and large drops when compared to summer rainfall. RSD stratified on the basis of rain rate showed a higher mass-weighted mean diameter (Dm) and a lower normalized intercept parameter (log10Nw) in summer than winter. Similarly, diurnal variation of RSD showed higher Dm and lower log10Nw values in summer as compared to winter rainfall. In addition, for both seasons, the mean value of Dm is higher in convective precipitation than stratiform. Radar reflectivity (Z) and rain rate (R) relations (Z = A*Rb) showed a clear demarcation between summer and winter rainfall. Higher ground temperatures, deeply extended clouds with intense convective activity in summer modified the RSD through evaporation, drop sorting, and collision-coalescence processes resulting with higher Dm and lower log10Nw values in summer ascompared to winter rainfall.

Keywords: raindrop size distribution; rain rate; radar reflectivity

D2-10

A sensitivity study of the ventilation effect and the hail's shape parameter on the structures of developing supercells

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Abstract: In this study we analysis the sensitivity of microphysics parameterizations that substantially affect the structures of developing supercells using the cloud-resolving model, WISCDYMM-II. We inspect two sets of parameterized equations: the ventilation effect on precipitation hydrometeors and the shape parameter of the particle size distribution of the hail. The ventilation effect could either enhance or reduce the diffusion growth rates of hydrometeors, depending on whether they are in supersaturated or subsaturated environments. Although the diffusion processes are believed to have minor impact on hydrometeor growths comparing to other microphysics processes, our simulations show altering the ventilation effect, which directly varies the diffusion growth rates, does change the structures of supercells significantly. On the other hand, the assumed particle size distributions are critical to storms in nature. In this part of the study, we control the shape parameter of the gamma distribution, which describes the hail sizes. Both the two sets of sensitivity investigations show significant changes in the structures of the developing storms. Consequently, they affect the precipitation magnitudes and durations, and the lifespans of the supercells. We analyze the cloud volumes, densities and mean particle sizes of hydrometeors at various altitudes and vertical wind speeds. This allows us to explore the distinctive natures of different hydrometeors in the convective cells and the stratiform regions separately. Our results show that increasing the ventilation effect increases the fraction of cloud volumes, and the masses and the mean particle sizes of precipitation hydrometeors in the convective cells. Changing the shape parameter of hailstone to allow for larger average diameter also results in increasing the convective fraction of cloud volumes, and masses and mean particle sizes of hail. These enhancements in the convective cells help to sustain the deep

convective systems, increase the maximum updrafts and downdrafts, and elongate the lifespans of storms.

Keywords: microphysics sensitivity; microphysics parameterization; ventilation effect; shape parameter; cloud-resolving model

D2-11

Remote Triggering Effect of a Tropical Cyclone in the Bay of Bengal on a Heavy Rainfall Event in Subtropical East Asia

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Abstract: Torrential frontal rainfall occurred over northern Taiwan on June 2, 2017. Prior to this rainfall, Tropical Cyclone (TC) Mora formed in the Bay of Bengal. This study investigated the triggering effect of TC Mora on the heavy rainfall system through numerical experiments. The numerical experiments, in which TC Mora was included or excluded in the initial conditions, revealed that TC Mora strengthened the southwesterly, which effectively transported tropical warm moist air toward Taiwan, and the cool dry northerly to the north of Taiwan. The strengthened southeasterly and northerly created a strong frontal system near Taiwan. TC Mora contributed to the heavy frontal rainfall by enhancing tropical-extratropical interaction and vertical coupling in East Asia.

Keywords: remote triggering effect; heavy rainfall; tropical cyclone

D2-12

Characteristics of the Marine Boundary Layer Jet over the South China Sea during the Early Summer Rainy Season of Taiwan

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Abstract: The marine boundary layer jets (MBLJs) over the northern South China Sea during the early summer rainy season over Taiwan are analyzed using 5-yr (2008–12) National Centers for Environmental Prediction Climate Forecast System Reanalysis data with a 6-h interval. The MBLJ is distinctly different from the low-level jets associated with the subsynoptic frontal systems. During this period, the MBLJ events over the northern South China Sea mainly occur during the second half of the monsoon rainy season over Taiwan (after 1 June) and have a wind speed maximum around the 925-hPa level. The MBLJs are mainly related to the subsynoptic-scale pressure gradients related to a relatively deep mei-yu trough over southeastern China and a stronger-than-normal west Pacific subtropical high. Within the MBL, there is a three-way balance among pressure gradients, Coriolis force, and surface friction, with cross-isobar ageostrophic winds pointing toward the mei-yu trough throughout the diurnal cycle. At the jet core, the vertical wind profile resembles an Ekman spiral with supergeostrophic winds >12 m s−1 near the top of the MBL. The MBLJs are strongest at night and close to geostrophic flow in the late afternoon/early evening. This is because the friction velocity and ageostrophic wind decrease during daytime in response to mixing in the lowest levels. The MBLJs play an important role in horizontal moisture transport from the northern South China Sea to the Taiwan area. With more intense moisture transport within the MBL from the northern South China Sea to the Taiwan area, more significant heavy rainfall occurs over Taiwan during MBLJ days than the climatological mean. In the frontal zone, the moisture tongue extends vertically upward. The rainfall production is related to vertical motions in the frontal zone or localized lifting due to orographic effects.

Keywords: boundary layer jet; rainfall; orographic effects

D3-01

Tropical cyclone structures as depicted by WWLLN data – Convection asymmetry

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Abstract: This study examines the lightning activity under the directions of vertical wind shear (VWS) and movement of tropical cyclones (TCs) over the western North Pacific. It is performed by the World Wide Lightning Location Network (WWLLN) and NCEP FNL operational global analysis data for 230 TCs between 2005 and 2017. The spatial distribution of lightning frequency and normalized lightning rate shows that the VWS dominates the appearance of the lightning. The flashes are active in the downshear-left side of the inner core, and that in the downshear-right side of the outer region. However, the asymmetric pattern is unobvious when sorting with the movement direction of TCs, only the flashes are slightly active in the front-left side of the inner core. Furthermore, the patterns of lightning distribution are almost the same between with and without considering the adjustment factor.

In addition, this study investigates the differences of TC lightning distribution in the different strength of environmental VWS and TC intensity. For the 3 categories of VWS, with the increasing VWS, the flashes of lightning are more asymmetric and higher proportion in the outer region of the downshear side. In the 3 categories of TC intensity, by contrast, the same features occur with the decreasing TC intensity. Furthermore, the calculation of the average lightning rate (total flashes/total time period) for the categories of different strength of VWS and TC intensity indicate that lightning occurs most frequently in the strong VWS and rarely occurs in the weak VWS; on the other hand, the lightning appears more frequently in the weak TC than that in the moderate and strong TCs. Based on a series of composite analyses, when the stronger TC intensity and weaker VWS, the lightning distribution is the more compact, and if the weaker TC intensity and stronger VWS, the lightning distribution is more asymmetric. Besides, it is found that there is the largest average lightning rate in the type of weak TC and strong VWS.

Keywords: lightning frequency; normalized lightning rate; lightning asymmetry

D3-02

Characteristics of Deep Convections and Associated Dynamic Conditions from Cloudsat Over the South China Sea and Maritime Continent

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Abstract: Deep convection plays an important role in the global climate. It affects not only the balance of radiation and the hydrological cycle but also transports polluted particles, energy and moisture from the boundary layer to the upper atmosphere, which might link to the greenhouse effect. We conduct the analysis of CloudSat and ERA-Interim data from 2007 to 2016, to identify the deep convective systems (DCS) over the Maritime Continent (MC) and the South China Sea (SCS). The associated vertical structure, horizontal span, dynamic environmental factors, and spatial and temporal characteristics of deep convection were analyzed to seek the possible atmosphere dynamic controls of deep convection in the targeting regions.

The results show that more isolated convective systems formed at MC (0.74% incidence) with more packed and larger particles at the upper-convective core (CTH-H_10dBZ: 3.43km). There are more organized convections formed over SCS (0.88% incidence) with more dispersed and smaller particles at the upper-convective core (CTH-H_10dBZ: 3.77km). The system horizontal span and echo height difference, rising velocity and the upper-level divergence are all positively correlated, especially, the deep convective core is highly sensitive to the ascending motion and the upper-level divergence (10-16 km). The vertical wind shear (VWS) less than 20ms-1 may increase the horizontal size of DCS, which is beneficial to the development of mesoscale systems. However, VWS over than 20ms-1 disperses the structure of the convective cloud, decreasing the occurrence frequency of the isolated system. Also, 10 km height is a critical threshold level, where the maximum vertical updraft velocity and the upper-level divergence.

Keywords: deep convection; CloudSat

D3-03

The Numerical Study of Severe Precipitation Induced by Local Circulation in Taiwan

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Abstract: A severe precipitation event occurring in western Taiwan under weak synoptic-scale forcing in the afternoon on 28th June 2010 is simulated with Weather Research and Forecasting (WRF) Model V 3.3.1 with 2 km horizontal resolution to assess the impact of complicated terrains, land-sea temperature contrast, and curvature of coast on such weather events. In order to understand the key factors affecting the direction and intensity of sea breeze circulation under weak synoptic-scale forcing, three sensitivity tests were performed. In the terrain removal case, the sea breeze circulation will not develop. In the flat terrain case, the severe precipitation occurs by convergence of westward and eastward sea breeze circulations. More horizontal convergence is observed in the convex coastline area which enhances the updraft and causes more precipitation. In the plain removal case, we find that the speed of sea breeze circulation decreases and therefore less precipitation occurs.

Keywords: sea breeze; severe precipitation; curvature of coast

D3-04

Mechanisms of Orographically Enhanced Precipitation Associated with Typhoon Meari (2011) over Mt. Da-Tun

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Abstract: With detailed analyses of rain gauge data and Doppler radar observations, this study is aimed to explore the physical mechanisms for the orographically enhanced precipitation associated with Typhoon Meari (2011). Mt. Da-Tun, the study area, is a three-dimensional, isolated mountain barrier located adjacent to the northern coast of Taiwan and has terrain peaks at around 1 km (MSL, Mean Sea Level). The heavy precipitation for this typhoon event was concentrated over this mountain barrier as Meari passed over regions ~300 km northeast of Taiwan and brought strong northerly/northwesterly flow (20-25 m s-1) impinging on northern Taiwan. Intense rainfall (>250 mm) was observed nearby the mountain crest of Mt. Da-Tun within 10 hours during the period of primary interest. Analyses indicate that the layer of orographic enhancement of precipitation was primarily confined to the lowest 3 km, with most pronounced enhancement below 2 km. The enhanced rainfall was observed to be 2-3 times greater than the typhoon background precipitation, which is comparable to previous studies.

By tracking hydrometeor trajectory and performing theoretically quantitative calculations, it is found that the increased amount of precipitation water as hydrometeors aloft fell into the low levels was closely related to the precipitation enhancement due to seeder-feeder processes. In addition, the enhanced precipitation over mountains could be much better quantified by theoretical accretion rate than upslope-lifting-induced precipitation.

Moreover, the error of seeder-feeder calculation was larger when convective cells embedded within typhoon background precipitation moved into Mt. Da-Tun. It implies

that the seeder-feeder processes are more suitable for stratiform background precipitation scenario, while the rainfall enhancement of convective cells cannot be simply explained by seeder-feeder processes.

Keywords: typhoon; orographic rainfall

D3-05

Reconstructed typhoon series 1644-1911 and implications of general atmospheric-oceanic circulation

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Abstract: This study used Reconstructed East Asian Climate Historical Encoded Series (REACHES) database (Wang et al. 2018) to reconstruct historical typhoon series in the East and South Coasts of China during the Qing dynasty (1644-1911). Among 98,221 documentary records in the Qing dynasty, we retrieved 1,538 records documented with ‘typhoon’ (Chinese character 颱) or ‘hurricane’ (颶), with descriptions of other compounding effects such as strong wind, torrential rain and storm surge to consist of the data set. To avoid repetition and multiple counting of the same typhoon event, records that have temporal (± 1 days) and spatial (±2∘degree latitude/longitude) proximity were combined to account for one single typhoon event. The method was based on the systematic database approach and the records were examined by researchers to check data quality.

The analysis shows in total 807 reconstructed typhoon events during the period, an average of 3.02 typhoon events per year. The reconstructed series demonstrate clear multi-decadal to centennial variabilities in the East and South Coasts. The 17th century was the period with active typhoon activities; fluctuation in the earlier half of the 18th century was relatively small and was followed by dynamic variations throughout the later 18th and 19th centuries. Typhoon activities had obvious spatial differences at interannual and decadal fluctuations, especially presenting 2-3 and 6-8 years periodicities through spectral analysis. The reconstructed series were validated through intercomparison with other reconstructed series (R=0.847 for South Coast and R=0.616 for East Coast). Additional comparison with sunspot (SS), Western Pacific sea surface temperature (SST), Atlantic Multidecadal Oscillation (AMO), and Pacific Decadal Oscillation (PDO) indices has revealed the changing temporal-spatial typhoon patterns to be associated with the general atmospheric-oceanic circulations over the centuries.

P01

Evaluating the role of physical parameterizations on the simulations of afternoon thunderstorm precipitation with a multi-moment bulkwater microphysics scheme in the WRF mode

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Abstract: The ice microphysics has great impact on the simulation and quantitative prediction of precipitation from deep convection systems, but the highly simplified representations of hydrometeor properties, such as ice crystal shape and density, may lead to large uncertainties. A multi-moment four-ice (pristine ice, aggregate, graupel, and hail) bulk microphysics scheme of NTU (National Taiwan University) has been implemented into the WRF (Weather Research and Forecasting) model version 3.8.1. The NTU scheme has four major improvements over current schemes in WRF: (1) applying triple-moment (the zeroth, second, and third moments) closure method, (2) permitting the crystal shape and apparent density to evolve with gradual adjustment according to growth conditions, (3) coupling the group fall speed of frozen particles to ice shape and density, and (4) re-defining the solid-phase hydrometeors by forming mechanisms. Events of violent precipitation associated with summer severe thunderstorms over the Taipei metropolis were simulated with the NTU scheme to investigate the roles of ice-phase processes in such events. Preliminary analyses and evaluations will be presented, including a comparison with results using other double-moment microphysics schemes in the WRF.

Keywords: ice habit; microphysics; WRF

P02

Doppler-radar derived vertical velocity using profiler data

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Abstract: The retrieval of vertical velocity using Doppler radar data always contains large uncertainty. In this study the quality of the vertical velocity retrieved by a 3DVar-based multiple-Doppler wind analysis system named WISSDOM (WInd Synthesis System using DOppler Measurement) is investigated. Data from one S-band (RCWF) radar and two C-band radars (RCTP and NCU) in northern Taiwan are utilized.

The accuracy of the vertical velocity from WISSDOM is examined using two profilers (L-band and UHF) observations. The inter-comparison shows that WISSDOM-derived vertical velocity agrees reasonably well with the profiler data. The highest correlation and the smallest RMSD (Root-Mean-Square Deviation) take place when comparing against the L-band profiler data obtained under vertical beam scanning mode. The WISSDOM-derived results are generally better than those reported in a previous study using ARM scanning radar network in Oklahoma. Finally, the winds from the L-band profiler are also merged into WISSDOM, resulting in an overall improvement of the three-dimension wind field at low levels.

Keywords: WISSDOM; profiler

P03

Cloud Top Features of Atmospheric Convections from Himawari-8

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Abstract: The life cycle of the convective system plays an important role in the atmospheric energy budget and hydrological cycle for its generation and maturity. However, due to the rapid development of the convective cloud system and the lack of direct observation limited spatiotemporal distribution, it is difficult to know the characteristic of convective cloud of the whole lifecycle. Therefore, this study uses large-scale and continuous satellite retrieval products and analyzes the characteristics of cloud top properties of the convection system.

Through the high temporal and spatial resolution of the geostationary satellite Himawari-8, we understand the characteristics of the early development of convective lifecycle. From band 14 window channel observing the cloud top brightness, we use the minimum brightness temperature to track convective systems. The satellite-retrieved parameter include cloud top height, cloud droplet effective radius and cloud optical thickness are analyzed, therefore the changes of cloud top properties from the cumulus cloud to mature deep convection are realized. It is found that the cloud top vertical velocity in Taiwan and the South China Sea is mostly centered below 2m/s. Five percent of the selected convections are able to develop to large vertical velocity of 6m/s or more. The maximum vertical velocity occurs are observed at 12-14km. The initial stage of convection is weak and vertical velocity is smaller. The maximum vertical velocity is on the middle stage and then slows down before maturity. In the South China Sea, the optical thickness of the convective cloud is larger than that in Taiwan and that occurs when the cloud top develops higher. The cloud droplet effective radius concentrates at 10-30 microns, and the effective radius in the South China Sea will develop much larger.

By geostationary satellites for rapid scanning and continuous observations at the same location, we analyze fast-moving convective systems with short life cycles, it can help to understand the characteristics of cumulus from development to maturity and to strengthen the prediction and warning of severe weather.

Keywords: convection; vertical velocity

P04

Investigation of the Cloud and Precipitation Properties of Deep Convective Core from CloudSat Observation

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Abstract: Both of clouds and precipitation play an important role in the hydrological cycle, particularly, Cumulonimbus (Cb) has the strongest impact on the hydrological cycle of all cloud species. For the radiative energy budget, Cb clouds absorb more long-wave radiation and reflect more short-wave radiation than the thin cirrus. In the development of Cb clouds, it is typically associated with the formation of severe precipitation. Therefore, it is easy to cause disasters (e.g., flash flooding and lightening) with intense rainfall in a short duration. In this study, satellite observation and retrieved data are using to analyze the relationship between the microphysical properties of deep convective core (DCC) and precipitation.

The Cloud Profile Radar (CPR) which is aboard on CloudSat in the NASA A-Train reflectivity data are using to identify the DCC. The DCC are classified into several categories by precipitation data which is access from JAXA GSMaP global precipitation product. The research domain is focused on South East Asia (SEA), Eastern United States (EUS), Central Africa (CA) and Central South America (CSA). The contour of frequency by altitude diagram (CFAD) for radar reflectivity (dBZ) shows the strong relationship between maximum echo height and rain rate. Furthermore, the effective radius (Re) and concentration (N) of cloud ice droplet also show different features in each rain rate category. Interestingly, the characteristics of DCC vertical structure are depended with location. The CFAD for dBZ, Re and N in different rain rate category are very similar in CA, however, the dBZ, Re and N are obvious increase with rain rate in others region. At each height, the effective radius of cloud droplets increase with rain rate in every regions, especially in SEA. The regional difference may be related to atmospheric states (e.g., relative humidity, wind speed, etc.), nevertheless, the vertical distribution of Re and N can be used as a good precursor of rainfall in deep convection events.

Keywords: Deep Convective Core (DCC); precipitation; satellite observations

P05

Afternoon Thunderstorm in Taipei Basin during Summer

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Abstract: Afternoon thunderstorm (ATS) at Taipei basin is well known as an important topic of forecast. We select 7 ATS cases without synoptic convection system near Taiwan. Rainfall pattern in these 7 ATS cases are similar: heavy rainfall concentrated Taipei city and rainfall intensity is over 30 mm hr-1. We also select 6 No-ATS cases whose date is closed to 7 ATS cases, but without rainfall in Taipei basin. Compare 7 ATS cases and 6 No-ATS cases, we could see that, 1) subsidence near 850 hPa in No-ATS cases, 2) land-sea breeze is clear in ATS cases, 3) low level specific humidity over 19 g kg-1 at estuaries before rain in ATS cases. We will composite these 7 cases as control run, and modify the parameter to meet the No-ATS cases to see how would it influence the convection and rainfall amount and position.

Keyword: afternoon thunderstorm

P06

A Case Study of Afternoon Thunderstorm in Taipei City: Characteristics of Rainfall Structure

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Abstract: In this study, observational characteristic of an urban flash flood case in Taipei basin associated with afternoon thunderstorm (14 June 2015) is examined using radar network around Taipei, includes WSR-88D polarimetric radar, and Parsivel disdrometer. The urban flash flood associated with afternoon thunderstorm is characterized with extreme rainfall intensity with short duration (almost 200 mm in 3 hours) and is closely related to the merge of severe convective cells.

From the surface analysis, the convergence, which composing of sea breeze coming into basin and the down-sloping cold pool due to earlier precipitation, is favorable of cell merging. The updraft regions coordinate with the convergence of lower level and the upward motion increase after the cells merge together. Large region of ZDR (differential reflectivity) is in the edge of updraft core before and lately after the merging stage. The merge of convective cells produces enlarged precipitation area and strong echoes that can extend to a much higher altitude. The appearance of KDP (specific differential phase) increasing toward ground accompany with downdraft suggests occurrence of heavy rainfall. Column of positive ZDR extended 2 km above the melting layer accompanies with strong updraft. Large amounts of big raindrop contained in this storm were observed by disdrometer. Comparison between the ZDR on ground and at 1 km height shows the size sorting effect in the beginning of rainfall. During heavy rainfall period, the collision–coalescence processes near surface could be speculated also.

Keywords: afternoon thunderstorm; severe rainfall; ZDR column

P07

Deep Convective Cloud Properties of Tropical Cyclone (TC) Meranti (2016): A Case Study of TC Intensity Change

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Abstract: Convective clouds in the inner core of a tropical cyclone (TC) are unique as within them are extremely deep, intense and rotational updrafts with relatively weak downdrafts. This study investigates the deep convective clouds' (DCCs) properties in the inner core of TC Meranti with respect to intensity changes. Infrared brightness temperature (IR BT) is used to identify DCCs and their properties such as cloud ice water path (CIWP), effective radius (CER) and optical thickness (COT). The study reveals that in the inner core, Meranti's intensification shifts the DCC's CIWP and COT preferences to higher values and increases the homogeneity of CER distribution. Additionally, rapid intensification and slowly weakening lowered the CER preference values, which coincide with associated wide and heavy precipitation. This behavior of CER in the inner core suggests a previously unknown connection between the precipitation and TC intensification and weakening.

Keywords: tropical cyclone; deep convective cloud; Meranti

P08

Developing Space-borne Quantitative Precipitation Estimation - Preliminary result on Typhoon Cases

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Abstract: The space-borne precipitation products have the advantage of global coverage and high spatiotemporal resolutions in comparison with ground-based precipitation observations. The objective of this study is to estimate the rainfall rate using the new generation Himawari-8 meteorological satellite with multi-band brightness temperature and cloud microphysical parameters,ground truth information obtained from CWB automatic weather stations scattered on Taiwan island.The Himawari-8 satellite data are at 2km×2km spatial resolution at a 10 minutes scale of the Typhoon MERANTI on 13-15 Sep,2016 was investigated in this study.In this study,the author uses the Back propagation Neural Network (BPNN) as research method to figure out the relationship between surface precipitation and cloud top parameters.

The performance of model is evaluated by a number of verification parameters,including real-valued precipitation accuracy and uncertainty estimation,and compared with operational product, Global Satellite Mapping of Precipitation (GSMaP),Integrated Multi-satellitE Retrievals for GPM (IMERG), Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks–Cloud Classification System (PERSIANN-CCS),respectively.The experiment shows that compared to rain gauge, all operational precipitation products underestimate the rainfall rate, and the underestimation increases with rainfall rate. The QPE model performance shows significant improvements when we categorized by cloud phase before training the model. For the real-valued precipitation estimation,the categorized model is 2% lower in RMSE,and has a 14% higher correlation coefficient. The performance is better when the cloud microphysical parameters is used.

Keywords: Himawari-8 meteorological satellite; Quantitative Precipitation Estimation(QPE); Back propagation Neural Network(BPNN)