出國報告（出國類別：國際會議）

赴日本沖繩參加 2019 年「中尺度對流系統與極端天氣國際研討會」

服務機關：交通部中央氣象局氣象資訊中心
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　　　　　李志昕　技士
派赴國家/地區：日本沖繩
出國期間：108 年 3 月 5 日至 108 年 3 月 10 日
報告日期：108 年 4 月 26 日

摘　要

中尺度對流系統與極端天氣國際研討會 International Conference on Mesoscale Convective System and High Impact Weather (ICMCS) 每一年半輪流在太平洋不同國家舉行會議，讓學術界、研究機構和社會大眾有機會針對重要的極端天氣問題交換彼此新知，以增進對災害成因的認識，並深入探討災害相關的議題，本年（108 年）於日本沖繩舉辦。

中央氣象局亦致力於極端天氣之研究發展，透由對增加區域預報數值模式之水平與垂直解析度進行許多研究，期望能提升模式對於環流與劇烈天氣、豪大雨等現象的預報能力，增進模式的預報參考價值和對於中小尺度系統的描述能力。江琇瑛技士在中央氣象局負責對流尺度雷達資料同化系統之研究發展；李志昕技士負責發展區域系集預報系統，自 106 年起持續進行區域系集預報系統之提高解析度之研發，本次會議兩人於會中發表最新之研究成果，和與會之專家學者進行分享和討論。此外，也於會中聆聽相關議題的新發展和了解各國數值預報作業現況，方能知己知彼，並且展望未來。

目 錄

壹、目的

梅雨及中尺度對流系統等極端天氣議題和全球經濟發展的未來，尤其是全球減災、防災的議題密切相關，我國透由積極參與國際間數值預報、劇烈天氣等議題相關研討活動以掌握國際脈動，並得以開拓在國際社會發聲的管道。中尺度對流系統與極端天氣國際研討會（ICMCS）是東亞天氣研究協會發起的一項計畫，由東亞和美國的氣象研究科學家聯合組織，目的為促進相關的研究人員和預報員之間的交流合作。第一次會議於 2000 年在首爾舉行，隨後的會議分別在臺北（2001 年、2007 年與 2017 年）、東京（2002 年）、北京（2004 年與 2013 年）、科羅拉多州博爾德（ 2006 年與 2014 年）、首爾（2009 年）、名古屋（2011 年）與釜山（2016 年），今年 ICMCS 則選定在沖繩舉行。

江琇瑛技士負責中央氣象局（以下簡稱氣象局）雷達資料同化技術發展，此行除了聆聽相關議題的科學進展外，並將於會議中發表論文，題目為「Application of the multi-scale blending scheme on continuous cycling radar data assimilation」；李志昕技士負責氣象局區域系集預報技術發展，於會中發表論文，題目為「Blending of regional analyses and EAKF forecasts with a spatial filter: application to the Taiwan ensemble prediction system」。參與此研討會發表個人研究成果論文，向國際科學家介紹臺灣在系集預報與對流尺度雷達資料同化最新發展及應用成果外，並可了解各國在劇變天氣研究與作業現況，同時增進與國際氣象作業界之交流及獲得回饋，相信對氣象局數值模式預報相關作業之未來推展極有助益。

貳、過程

2019 年中尺度對流系統與極端天氣國際研討會於 108 年 3 月 6 日至 8 日在日本沖繩舉行，江、李二員於 3 月 5 日自臺北出發，於 3 月 6 日至 8 日參加研討會。

日期	地點	工作記要
108 年 3 月 5 日	臺灣-日本沖繩	江員、李員搭機前往日本沖繩。
108 年 3 月 6 - 8 日	日本沖繩	參與「ICMCS」研討會。
108 年 3 月 9 日	日本沖繩-臺灣	李志昕技士自沖繩那霸機場搭機返回臺灣。
108 年 3 月 10 日	日本沖繩-臺灣	江琇瑛技士自沖繩那霸機場搭機返回臺灣。

此次研討會論文內容十分豐富，主要為大氣科學領域之研究，包含定量降雨估計、中尺度對流系統與梅雨鋒面研究、熱帶氣旋之研究、資料同化與對流尺度預報、新興觀測技術、短延時強降水之預報，以及災害防治等議題，從氣象觀測到天氣系統之原理研究、數值天氣預報模式研究，以及災害防治，皆有所涵蓋與討論，共計有 65 篇口頭論文發表，以及 108 篇海報論文發表，江、李二員各發表一篇論文，簡略議程如下，完整議程如附錄一：

3 月 6 日，第一天議程	
09:00 - 10:00	報到與開幕
10:00 - 12:00	Keynote Presentation
13:15 - 14:45	Poster Presentation 李員於此議程發表論文。
15:00 - 17:30	Tropical Cyclone (I)
3 月 7 日，第二天議程	
09:30 - 11:15	Mesoscale Convective Systems (I)
11:30 - 13:30	Observation Technique and Field Campaign

14:30 - 16:00	Poster Presentation
16:15 - 17:30	Tropical Cyclone (II)
3 月 8 日，第三天議程	
09:30 - 11:30	Numerical Simulation and Data Assimilation 江員於此議程發表論文。
11:45 - 13:30	Tropical Cyclone (III)
14:30 - 16:15	Monsoon Orographic Rainfall and Others
16:30 - 18:30	Tropical Cyclone (IV) and QPE

江員發表論文題目為「Application of the multi-scale blending scheme on continuous cycling radar data assimilation」。主要內容為探討多重尺度混合法應用於雷達資料同化系統，對於模式定量降水預報之影響（研討會摘要於附錄二，簡報資料於附錄三）。由於短延時、強降水天氣系統往往具有系統快速演變與劇烈降水過程，故模式可預報度相當有限，而具有快速更新頻率並且伴隨高模式解析度的雷達資料同化系統，是提高短延時、強降水天氣系統之模式可預報度的重要關鍵。不過，在快速循環更新的資料同化策略中，容易累積模式的預報誤差，這些誤差來源可來自模式動力過程、模式物理參數法等問題。本研究使用氣象局之三維變分法（three-dimensional variational，3DVAR）與局地系集卡爾曼濾波（local ensemble transform kalman filter，LETKF）雷達資料同化系統，探討如何透由多重尺度混合法結合全球模式分析場和對流尺度雷達資料同化系統初始猜測場，抑制雷達資料同化循環更新過程所累積的模式誤差，進以提高模式定量降水預報能力。結果顯示，在連續循環雷達資料同化系統中配合多重尺度混合法，可改善模式水氣的累積誤差，進以提升模式定量降水預報表現，不論是 3DVAR 和 LETKF 雷達資料同化系統，皆是如此。

李員發表論文題目為「Blending of regional analyses and EAKF forecasts with a spatial filter: application to the Taiwan ensemble prediction system」，發表氣象局區域系集預報系統之最新進展，主要為針對系統模式初始場之不穩定問題進行強化（研討會摘要於附錄四，論文全文於附錄五）。原本之系集預報初始場，透過簡單之加法，疊加區域決定性預報分析場和系集卡爾曼濾

波系統（ensemble adjustment kalman filter，EAKF）之預報場，會產生較多的小擾動，造成模式預報不穩定，預報表現也較差，因此欲改用混合法(blending scheme)結合區域決定性預報分析場和 EAKF 預報場，透過濾波方式擷取決定性預報分析場之大尺度資訊和 EAKF 小尺度資訊，並將兩個資料結合，據以得到較佳且較穩定之系統初始場。此外，並評估 blending scheme 中截斷長度（ cut-off length）之選擇，對預報表現之影響。預報結果指出，此法能有效降低原本過多的小擾動，改善模式預報之穩定度，亦能有效改善颱風路徑預報誤差表現，其中又以 cut-off length 為 1200 公里之設定能獲得最佳的表現。會中和國內外學者分享此研究成果，皆獲得正面之迴響。

另會議中，氣象局數值模式小組發表三篇論文，包含：

1. 「Introduction to CWB’s HRLDAS and evaluation of the impact of surface parameters on HRLDAS over Taiwan」，內容探討氣象局之高解析度土壤資料同化系統（High Resolution Land Data Assimilation System，HRLDAS），此系統可以提供氣象局區域數值天氣模式較佳的土壤溫度及土壤濕度資訊。研究中指出在定性上的比較，HRLDAS 的土壤溫度與濕度明顯比美國國家環境預報中心（NCEP）之資訊還要合理；定量上的比較，HRLDAS 的土壤溫度有冷偏差的狀況。
2. 「Development of blended quantitative precipitation forecast product」，氣象局發展混合式定量降水預報（blended quantitative precipitation forecast，BQPF），目標在於整合多元定量降水預報指引，發展有效的單一逐時滾動更新的逐時定量降水預產品，未來可供防災需求之用。此研究收集氣象局之多元定量降水預報類型，包括雷達外延之定量降水資料、區域中尺度模式決定性預報與系集預報系統，與利用影像辨識技術比對挑選系集成員之極短期預報（iTEEN）等進行資料整合，並產製 BQPF 產品。研究中進行客觀校驗與個案研究以了解在顯著降雨事件時的統計特性。分析結果指出，BQPF 能展現出不錯的預報效能，表示此客觀產品可以做為有效的參考指標。
3. 「Application of the model perturbation scheme in the convective-scale ensembles predict system」，氣象局發展兩公里解析度之對流尺度系集預報系統，以了解午後暴雨等高影響天氣系統。原僅使用 LETKF

產生系集模式擾動，但離散度表現不佳，因此欲評估透過隨機動能後向散射法（Stochastic Kinetic Energy Backscatter Scheme，SKEB)產生模式擾動，對於預報表現之影響。研究結果指出調整 SKEB 中之參數設定，如增加模式擾動振幅能有效改善離散度之表現。

此外，於會中聽取國內外學者之最新研究，數值天氣預報模擬之研究成果，有一些值得參考之成果：

1. 日本京都大學 Pin-Ying Wu 博士進行 LETKF，於對流尺度系統中，進行雷達資料同化相關研究。研究中針對不同數量之系集預報成員，以及局地化參數（localization）大小進行敏感性測試，指出較大數量之系集成員（256 個成員），以及較小的水平 localization 及較大的垂直 localization 能獲得較佳的分析場。此研究和氣象局正在發展之雷達資料同化技術類似，期望能從中獲得想法，例如評估增加系集預報成員，以強化氣象局雷達系集資料同化系統。
2. 日本理化學研究所以高速電腦所做的研究顯示，當衛星、先進雷達（例如陣列雷達）觀測資料的時空解析度都增加後，同化大數據到高解析度與高更新頻率的資料同化及系集預報系統，準確地針對短延時強降水天氣系統提供高頻率的預報和預警。
3. 倫敦帝國學院之 Ralf Toumi 博士針對熱帶氣旋個案，進行資料同化研究，高頻率雷達能提供高解析度和高頻率之海流資料，在熱帶氣旋登陸前之個案，透過 EAKF 同化此一資料，能有效改善熱帶氣旋之強度，最大風速的誤差改善能達到 60%。
4. 日本國立研究開發法人海洋研究開發機構之 Tsutao Oizumi 博士，進行高解析度和不同數值模式範圍之研究。結果指出數值模式解析度 500 公尺之預報表現會優於 2 公里解析度，而 5 公里解析度表現最差。此外，使用較大的模式範圍之預報結果會優於小範圍。
5. 中央大學陳舒雅博士使用跨尺度預報模式（Model for Prediction Across Scales，MPAS），評估同化衛星無線電掩星（radio occultation，RO）資料對模式之影響，針對 2016 年尼伯特颱風個案進行預報實驗，預報結果指出同化無線電演星資料能有效改善模式路徑預報表現。

此外觀測實驗的分析與模擬之研究，包含：

1. 日本之 T-PARCII 團隊(Tropical cyclones-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts)與臺灣之追風計畫團隊聯合飛機觀測，使用投落送探空儀進行 2017 年強烈颱風蘭恩之觀測，實驗能觀測到颱風內核區的熱動力結構，此資料應用至數值天氣預報模擬時，能可顯著改善數值天氣預報之颱風中心氣象預報和路徑預報。
2. 對於颱風眼區對流之演變，雷達觀測和衛星觀測結果不盡然一致，因此會影響颱風中心氣壓推估的結果。
3. 北京大學 Rumeng Li 博士，針對智慧型手機的氣壓感應元件，進行資料分析、資料品質控制和資料誤差修正，結果發現資料在夏季、白天資料較多，此外在劇烈天氣時也有較多的資料，雖然只是初步研究成果，但未來有機會能提供劇烈天氣之應用。

叁、心得及建議

本次研討會中，在數值天氣預報之議題上，相關研究有往對流尺度預報之發展趨勢，因此研發過程中所面臨到的問題和解決策略，皆能提供中央氣象局數值天氣預報小組發展上之借鏡，同時，亦證明與氣象局數值預報小組之發展方向相符，並能有不錯的成果和各專家學者分享。此外，在系集預報發展上，有多位學者正在測試增加系集預報成員之研究，亦有不錯之預報表現，期望未來能提高氣象局高速運算電腦資源，以針對此議題進行評估。

隨著數位科技的進步，研討會的議題中，機器學習的研究也越來越多，此外還有透過智慧型手機觀測氣壓之資料分析，研究內容與時俱進，也提供更多不同面向的想法。此外，此次研討會並未提供紙本或是光碟片之論文集，僅提供簡單的議程紙本，所有論文摘要在會議前已放在官方網站中，提供與會者參考。由於現在包含手機、平板電腦和筆記型電腦等行動裝置和網路的普及，與會者皆能在會議中於網站上閱讀摘要，此法不僅未造成

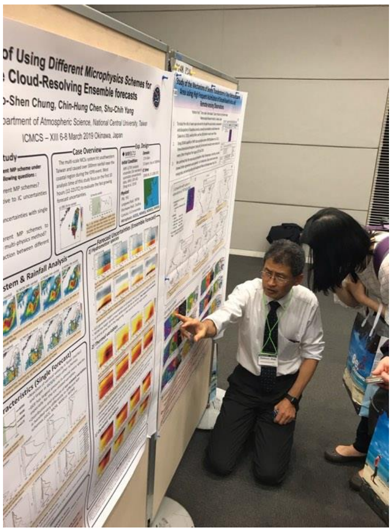
困擾，能減少紙類或是光碟片的使用，與會者也不需帶著厚重的論文集移動，既環保亦能減少經費支出，能提供未來舉辦相關會議之參考。

過去ICMCS研討會較多側重於中尺度對流系統和高影響天氣的學術研究，以及觀測實驗的經驗和成果分享，近年來逐漸受到業務單位重視，包含美國國家海洋暨大氣總署（National Oceanic and Atmospheric Administration，NOAA）、日本氣象廳（Japan Meteorological Agency，JMA）、韓國氣象廳（Korea Meteorological Administration, KMA）、中國氣象局（China Meteorological Administration，CMA）等皆參與，江、李二員除獲取研究及技術的知能外，也有機會與其他作業單位交流研發經驗和成果，有助於我了解氣象局目前在國際上的定位及展望未來可能的發展規劃。

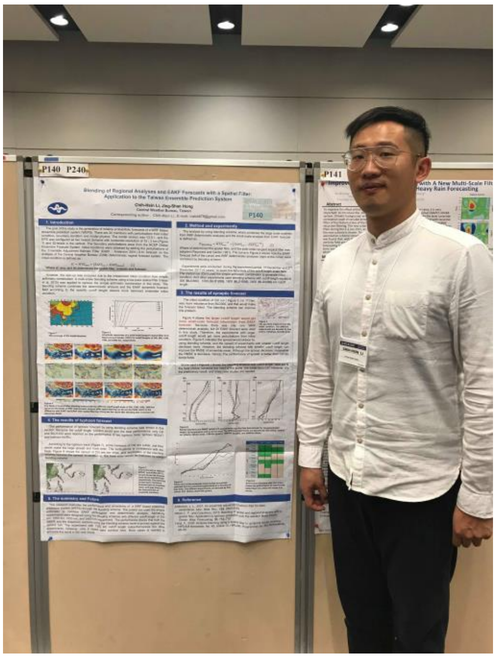
肆、照片

2019 年「International Conference on Mesoscale Convective System and High Impact Weather (ICMCS)」與會者合影

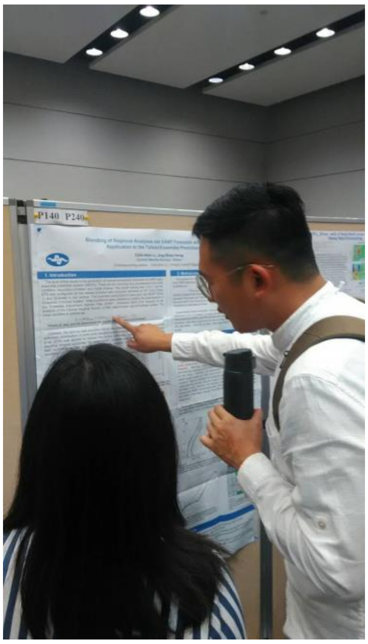
江琇瑛技士發表論文



江琇瑛技士與與會學者交流



李志昕技士與發表論文合影



李志昕技士與與會學者交流

伍、附錄

附錄一、研討會完整議程

March 6, 2019 (Wednesday)

	9:00	Registration
	9:45	Opening Remarks
	Keynote Session	Chair SeonKi Park (Ewha Womans Univ.) Tetsuya Takemi (Kyoto Univ.)
K101	10:00	Overview of T-PARCII aircraft observations of typhoons in 2017 and 2018 Kazuhisa Tsuboki (Nagoya Univ.)*, Taro Shinoda, Nobuhiro Takahashi, Hiroyuki Yamada, Kosuke Ito, Tadayasu Ohigashi, Munehiko Yamaguchi, Tetsuo Nakazawa, Hisayuki Kubota, Yukihiro Takahashi, Norio Nagahama, Kensaku, Shimizu
K102	10:20	ICE-POP 2018: Overview and preliminary results GyuWon Lee (Kyungpook National Univ.)*, Kwonil Kim
K103	10:40	Diagnosis of the Dynamic Efficiency of Latent Heat Release and the Rapid Intensification of Supertyphoon Haiyan (2013) Hung-Chi Kuo (National Taiwan Univ.)*, Satoki Tsujino, Chien-Chang Huang, Chung-Chieh Wang, Kazuhisa Tsuboki
K104	11:00	Warm-Sector Heavy Rainfall in Southern China and its WRF Forecast Evaluation: A Low-Level Jet Perspective Murong Zhang, Zhiyong Meng (Peking Univ.)*
K105	11:20	Heating, Cooling, and Circulation in Tropical Cyclones Michael M. Bell (Colorado State Univ.)*
K106	11:40	Big Data Assimilation: Past 5 Years and Perspectives for the Future Takemasa Miyoshi (RIKEN Center for Computational Science)*, Shigenori Otsuka, Takumi Honda, Guo-Yuan Lien, Yasumitsu Maejima, Yoshito Yoshizaki, Hiromu Seko, Hirofumi Tomita, Shinsuke Satoh, Tomoo Ushio, Tatiana V. Martsinkevich, Balazs Gerofi, Yutaka Ishikawa
	12:00	Group Photo
	12:10	Lunch

	13:15	**Poster Presentation (Day 1)**
	14:45	**Break**
	Session 1	**Tropical Cyclone (I)**
		Chair Kazuhisa Tsuboki (Nagoya Univ.) **Michael M. Bell (Colorado State Univ.)**
A107-I	15:00	**Recent Observations in Tropical Cyclones Using small Unmanned Aircraft Systems** **Joseph J. Cione (NOAA)*, George Bryan**
A108-I	15:15	**Observations of the Intensification of a Weak Tropical Cyclone in Moderate Vertical Shear** **Robert Rogers (NOAA/AOML Hurricane Research Division)*, Jonathan Zawislak, Paul Reasor, Leon Nguyen**
A109-I	15:30	**Relationships among MJO, tropical cyclones, and high-pressure disturbances in the subtropical High seen in the NICAM aqua-planet experiment** **Shin-ichi Moriizumi, Masanori Yoshizaki (Rissho Univ.)*, Yuusuke Kobayashi**
A110-I	15:45	**SST Modulation of the Impacts of Tropospheric Stability on the Intensity and Structure of Tropical Cyclones** **Tetsuya Takemi (Kyoto Univ.)*, Shota Yamasaki**
A111	16:00	**Improved Tropical Cyclone Intensity Forecasts by Assimilating Coastal Surface Currents in an Idealized Study** **Ralf Toumi (Imperial College London)*, Yi Li**
A112	16:15	**The impacts of cold eddies on the intensity changes during the mature phase of Typhoon Trami (2018)** **Akiyoshi Wada (MRI/JMA)*, Yoshinori Oikawa**
A113	16:30	**Tropical Clouds and Precipitation Systems "Across Scales" in Convection-Permitting Aquaplanet Simulations** **Rosimar Rios-Berrios (NCAR)*, Brian Medeiros, George Bryan**
A114	16:45	**Development of upstream low-level humidification and selective ensemble methods for short-term precipitation prediction system** **Yasutaka Wakazuki (Ibaraki Univ.)*, Daichi Igarashi**
A115	17:00	**Detection of water-soluble ions in hailstones: An effective way to investigate aerosols in deep convection** **Xiaofei Li (Peking University)*, Qinghong Zhang, Tong Zhu, Zejun Li, Jipei Lin, Tian Zou**
A116	17:15	**Important Factors for Development of Meso-beta Scale Vortex that Spawned Tornado-like Vortices** **Eigo Tochimoto (Univ. Tokyo)*, Sho Yokota, Hiroshi Niino, Wataru Yanase**
	17:30	**End**
	18:30	**Welcome Dinner at Fine Dinning Kenny's Omoromachi** 1-1-2 Omoromachi, Naha, Okinawa, Tel. +81-98-861-3007

March 7, 2019 (Thursday)

	Session 2	Mesoscale Convective Systems (I)	
		Chair	Wen-Chau Lee (NCAR) GyuWon Lee (Kyungpook National Univ.)
A201-I	9:30	Quasi-stationary band-shaped precipitation systems, named as "senjo-kousuitai", causing localized heavy rainfall in Japan Teruyuki Kato (JMA)*, Hiroshige Tsuguti, Yasutaka Hirokawa	
A202-I	9:45	Evolution of Microphysical Structure of a Subtropical Squall Line in Eastern China Kun Zhao (Nanjing Univ.)*	
A203-I	10:00	Sensitivity of hail precipitation to ensembles of uncertainties of representative initial environmental conditions Qinghong Zhang (Peking Univ.)*, Xiaofei Li, Fuqing Zhang, Matthew Robert Kumjian	
A204	10:15	Banded Convective Activity Associated with Mesoscale Gravity Waves over Southern China Yu Du (Sun Yat-sen Univ.)*, Fuqing Zhang	
A205	10:30	Convective cells embedded in widespread stratiform echoes observed by Kobe PAWR in July 2018 Shinsuke Satoh (NICT)*, Tetsuya Sano, Hiroshi Hanado, Shigenori Otsuka, Takemasa Miyoshi	
A206	10:45	Effect of the Sea Surface Temperature on Mesoscale Convective System-Produced Extreme Rainfall over Yellow Sea: 13 August 2012 Yunhee Kang (Pukyong National Univ.)*, Dong-In Lee, Jong-Hoon Jeong	
A207	11:00	Organizational Modes of Mesoscale Convective Systems associated with Warm-Sector Heavy Rainfalls in South China Sa Li (Peking Univ.)*, Zhiyong Meng	
	11:15	Break	
	Session 3	Observation Technique and Field Campaign	
		Chair	Ming-Jen Yang (National Taiwan Univ.) Kun Zhao (Nanjing Univ.)
A208-I	11:30	Airborne Phased Array Radar (APAR): The Next Generation of Airborne Polarimetric Doppler Weather Radar Wen-Chau Lee (NCAR)*, Louis Lussier, Vanda Grubišić	

A209	11:45	**Maritime Water Vapor Estimation using Ocean Platform GNSS Measurement** Yoshinori Shoji (MRI)*, Teruyuki Kato, Yukihiro Terada, Toshitaka Tsuda, Masanori Yabuki
A210	12:00	**Smartphone Pressure Observation from Chinese Moji users in 2016: Statistical Characteristics, Application and Bias Correction** Rumeng Li (Peking Univ.)*, Qinghong Zhang
A211	12:15	**Development of next-generation 1.3 GHz wind profiler radar** Masayuki K. Yamamoto (NICT)*, Seiji Kawamura, Koji Nishimura, Kosei Yamaguchi, Eiichi Nakakita
A212-I	12:30	**Multiscale Atmospheric Conditions in the Evolution of Convective Organization during MJO-1 of DYNAMO/CINDY/AMIE** Jeffrey D. Thayer, Deanna A. Hence (Univ. Illinois Urbana-Champaign)*, Piyush Garg, Stephen W. Nesbitt
A213-I	12:45	**Analysis and Forecast Using Dropsonde Data from the Inner-Core Region of Tropical Cyclone Lan (2017) Obtained during the First Aircraft Missions of T-PARCII** Kosuke Ito (Univ. Ryukyus)*, Hiroyuki Yamada, Munehiko Yamaguchi, Tetsuo Nakazawa, Norio Nagahama, Kensaku Shimizu, Tadayasu Ohigashi, Taro Shinoda, Kazuhisa Tsuboki
A214	13:00	**Field Campaigns in South China Sea Two Islands Monsoon Experiment (SCSTIMX) 2017-2018 and Its Extended Plan** Po-Hsiung Lin (National Taiwan Univ.)*, Chung-Hsiung Sui, Wei-Ting Chen
A215	13:15	**Airborne measurements for investigation of meteorological phenomena over Korea using the KMA/NIMS atmospheric research aircraft** Chulkyu Lee (NIMS/KMA)*, Suengpil Jung, Ji Hyoung Kim, Hyojin Yang, Heejong Ko, Jongwhan Yun, Sangwon Joo
	13:30	**Lunch**
	14:30	**Poster Presentation (Day 2)**
	16:00	**Break**

	Session 4	**Tropical Cyclone (II)**	
		Chair	**Qinghong Zhang (Peking Univ.)**
			Deanna A. Hence (Univ. Illinois Urbana-Champaign)
A216-I	**16:15**	**The Impacts of Vortical Hot Towers on the Inland Eyewall Reformation of Typhoon Fanapi (2010) over Taiwan**	
			Ming-Jen Yang (National Taiwan Univ.)*, Yao-Chu Wu, Yu-Cheing Liou
A217-I	**16:30**	**Near-shore rapid changes in tropical cyclone intensity**	
			Johnny C L Chan (City Univ. Hong Kong)*
A218	**16:45**	**An observational study of the inner-core evolution of Typhoon Jebi (2018) at landfall**	
			Udai Shimada (MRI/JMA)*, Ryo Oyama, Shingo Shimizu
A219	**17:00**	**Are outer tropical cyclone rainbands similar to squall lines?**	
			Che-Yu Lin (National Taiwan Univ.)*, Cheng-Ku Yu
A220	**17:15**	**Characteristics of convective bursts in the rapidly intensified Typhoon Trami (1824)**	
			Ryo Oyama (MRI/JMA)*
	17:30	**End**	
	18:30	**Bunquet at Pine Tree Bless Restaurant and Bar**	
		3rd floor, 4-1, Omoromachi, Naha, Okinawa, Tel. +81-98-941-3335	

March 8, 2019 (Friday)

	Session 5	Numerical Simulation and Data Assimilation
		Chair Dong-In Lee (Pukyong National Univ.) Zhiyong Meng (Peking Univ.)
A301-I	9:30	Improvements of two variational-based radar data assimilation systems and their applications in analyzing heavy rainfall processes
		Yu-Chieng Liou (National Central Univ.)*, Ying-Jhang Wu, Yung-lin Teng, Po-Chien Yang, I-An Chen, Shao-Fan Chang
A302	9:45	Consistent treatment of hydrometeors and cloudiness for convection and radiation processes in a numerical forecasting model
		Song-You Hong (KIAPS)*, Soo Ya Bae, Raeseol Park
A303	10:00	Data Assimilation Studies using Big Observation Data in the Projects of Post K and BDA
		Hiromu Seko (MRI/JMA, JAMSTEC)*, Masaru Kunii, Sho Yokota, Kosuke Ito, Kazuki Shimoji
A304	10:15	Predictability of the extreme precipitation event in Taiwan during 1-3 June 2017 based on the convective-scale ensemble data assimilation and prediction
		Shu-Chih Yang (National Central Univ.)*, Hsiang-Wen Cheng
A305	10:30	What is the source of chaos in MCS?
		Takuya Kawabata (MRI/JMA)*, Genta Ueno
A306	10:45	Application of the Multi-scale Blending Scheme on Continuous Cycling Radar Data Assimilation
		Jiang, Siou-Ying (National Taiwan Univ.)*, Ya-Ting Tsai, Jing-Shan Hong, Ben Jong-Dao Jou
A307	11:00	Assimilating Doppler radar observations with an ensemble Kalman filter for the convective development prediction in a heavy rainfall event over South China
		Xinghua Bao (CAMS)*, Yali Luo, Jiaxiang Sun, Zhiyong Meng, Jian Yue
A308	11:15	Simulation of Aviation Turbulence near the Cirrus Bands in East Asia
		Jung-Hoon Kim (Seoul National Univ.)*
	11:30	Break

	Session 6	Monsoon Orographic Rainfall and Others
		Chair Yu-Chieng Liou (National Central Univ.)
		Cheol-Hwan You (Pukyong National Univ.)
A309-I	11:45	The analysis of lightning characteristics using LINET and weather radar in Korea.
		Dong-In Lee (Pukyong National Univ.)*, Mi-Young Knag, Cheol-Hwan You
A310	12:00	Environments of High-Incidence Area for Warm-Season Tornadoes in China and a Comparison with Its Counterparts in US
		Ruilin Zhou (Peking Univ.)*, Zhiyong Meng
A311	12:15	Radar Observation of parent clouds of tornadoes in Tosa Bay
		Koji Sassa (Kochi Univ.)*, Akira Nishii
A312	12:30	Impacts of cyclogenesis and moisture transport by the marine boundary layer jet on heavy rainfall over southern Taiwan during SCSTIMX
		Yi-Leng Chen (Univ. Hawaii Manoa)*, Chuan-Kai Wang, Chuan-Chi Tu, Pay-Liam Lin
A313	12:45	Characteristics of extreme convective systems in the East Asian monsoon as seen by TRMM
		Kristen L. Rasmussen (Colorado State Univ.)*, Warittha Panasawatwong, Michael Bell
A314	13:00	Characteristics of the Marine Boundary Layer Jet over the South China Sea during the Early Summer Rainy Season of Taiwan
		Chuan-Chi Tu (National Central Univ.)*, Yi-Leng Chen, Pay-Liam Lin, Yu Du
	13:15	Lunch

	Session 7	Tropical Cyclone (III)
		Chair Hung-Chi Kuo (National Taiwan Univ.)
		Anthony C. Didlake, Jr. (Pennsylvania State Univ.)
A315-I	14:15	TBD
		Nancy Hann (NOAA)*
A316-I	14:30	The Influences of Sumatra Island and Synoptic Features on Tropical Cyclone Formation in the Indian Ocean: A Numerical Study
		Chung-Chieh Wang (National Taiwan Normal Univ.)*, Shin-Kai Ma, Richard H. Johnson

A317	14:45	Relationships between Shear-relative Lower-tropospheric Flow and the Intensity and Size Changes of Tropical Cyclones
		Buo-Fu Chen (National Taiwan Univ., NCAR)*, Christopher A. Davis, Ying-Hwa Kuo
A318	15:00	Asymmetric Intensification Processes of a Category 4 Super Typhoon Lan (2017) during High Vertical Wind Shear
		Sachie Kanada (Nagoya Univ.)*, Akiyoshi Wada, Kazuhisa Tsuboki
A319	15:15	Influence of Southwest Monsoon Flow and Typhoon Track on Taiwan Typhoon Rainfall during the Exit Phase
		Yu-Han Chen (National Taiwan Univ.)*, Hung-Chi Kuo, Chung-Chieh Wang, Yi-Ting Yang
A320-I	15:30	Impact of Dry Midlevel Air on the Tropical Cyclone Outer Circulation
		Shuai Wang (Univ. London, Imperial College London)*, Ralf Toumi
A321	15:45	Relationship between Typhoon Track Forecasts and Heavy Rainfall in Western Japan in July 2018
		Takeshi Enomoto (Kyoto Univ.)*
A322	16:00	The lightning distribution of tropical cyclones over the western North Pacific
		Shu-Jeng Lin (.Chinese Culture Univ.)*, Kun-Hsuan Chou
	16:15	Break
	Session 8	Tropical Cyclone (IV) and QPE
		Chair Chung-Chieh Wang (National Taiwan Normal Univ.)
		Taro Shinoda (Nagoya Univ.)
A323-I	16:30	New observation strategies for typhoon intensity over the western North Pacific
		Hiroyuki Yamada (Univ. Ryukyus)*, Kazuhisa Tsuboki, Taro Shinoda, Hisayuki Kubota, Yukihiro Takahashi, Norio Nagahama, Kensaku Shimizu, Kosuke Ito, Tadayasu Ohigashi, Munehiko Yamaguchi, Tetsuo Nakazawa
A324-I	16:45	Asymmetric Aspects of Secondary Eyewall Formation in Tropical Cyclones
		Anthony C. Didlake, Jr. (Pennsylvania State Univ.)*
A325	17:00	Tropical cyclones in global cloud-resolving simulations
		Falko Judt (NCAR)*

A326	17:15	**Evaluation of FAMIL2 in Simulating the Climatology and Seasonal-to-Interannual Variability of Tropical Cyclone Characteristics**
		Qing Bao (LASG/IAP/CAS)*, Jinxiao Li, Yimin Liu, Guoxiong Wu
A327-I	17:30	**A statistical approach on radar rainfall estimates using polarimetric variables in Korea**
		Cheol-Hwan You (Pukyong National Univ.)*, Mi-Young Kang, Dong-In Lee
A328	17:45	**Microphysical Characteristics of Different seasons and type of Precipitation over north Taiwan**
		Meng-Tze Lee, Pay-Liam Lin (National Central Univ.)*, Wei-Yu Chang, Balaji Kumar Seela, Jayalakshmi Janapati
A329-I	18:00	**Variations of ZDR and KDP in Heavy Rain Storms in Taipei**
		Ben Jong-Dao Jou (National Taiwan Univ.)*, Radiant Rong-Guang Hsiu, Ultimate Chi-June Jung
A330-I	18:15	**What does a positive KDP-peak layer above the melting level indicate? ~ Statistics of KDP profiles obtained by a Ka-band polarimetric radar ~**
		Taro Shinoda (Nagoya Univ.)*, Tadayasu Ohigashi, Hiroyuki Yamada, Yukiya Minami, Kazuhisa Tsuboki
	18:30	**End**
	19:00	**Committee Meeting (Invitation only)**

附錄二、江琇瑛技士研討會摘要

Application of the Multi-scale Blending Scheme on Continuous Cycling Radar Data Assimilation

Jiang, Siou-Ying[1*], Ya-Ting Tsai[2], Jing-Shan Hong[2], and Ben Jong-Dao Jou[1]
[1]*Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan*
[2]*Central Weather Bureau, Taipei, Taiwan*
E-mail: jouben@ntu.edu.tw

Abstract

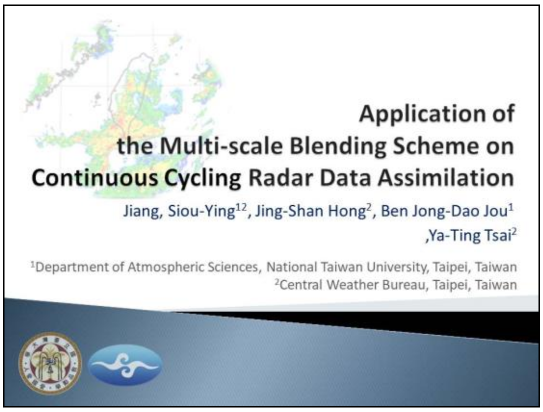
The predictability of the short duration extreme rainfall system is very limited due to the fast evolution and strong nonlinearity nature. The assimilation of radar observation with rapid update cycle frequency and high resolution model is a key to level up the predictability of such systems. However, the spin-up problem becomes more serious in the frequent update continuous cycle. It could introduce significant model error and hurt the first guess in data assimilation (DA). Therefore, how to handle the model error well is one of the important issues to provide the reliable first guess in the frequent update continuous cycle.

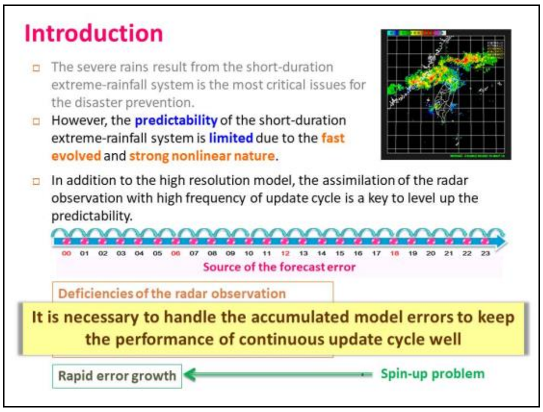
In order to reduce the model error in the first guess, the multi-scale blending scheme using a low-pass spatial filter was applied to continuous hourly cycling radar DA system. The blending scheme combines the global model analysis and the convective scale model forecast which take the advantage from the two models. WRF 3DVAR based deterministic DA and LETKF (Local Ensemble Transform Kalman Filter) based ensemble DA experiments were conducted to evaluate the effect of the blending scheme to reduce the accumulated model error in an hourly full cycle strategy. The blending scheme is to reduce the accumulated model error in the deterministic first guess in 3DVAR and re-center the ensemble mean in LETKF.

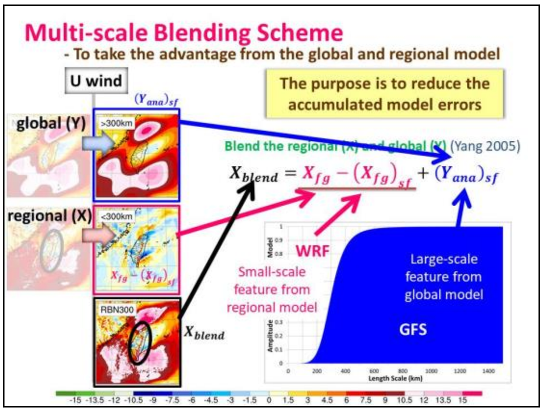
Case studies show that the both 3DVAR and LETKF radar DA with blending scheme provide consistently better FSS scores in all rainfall thresholds. The blending scheme is workable to reduce the accumulated model error from the continuous hourly cyclic radar data assimilation. In addition, the results also show that the improvement from 3DVAR is more significant than that from LETKF.

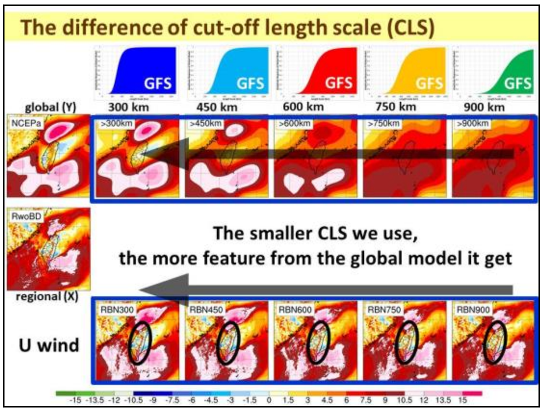
Key words: model error, frequent, spin-up, blending scheme

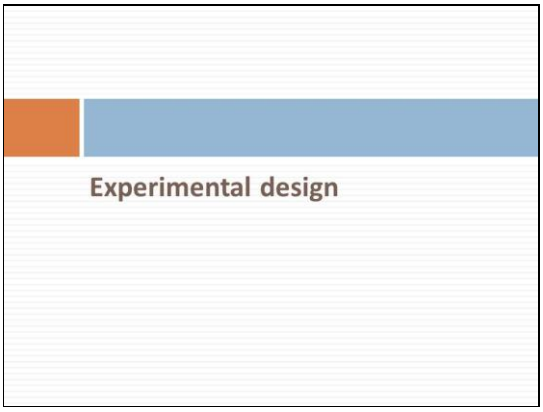
附錄三、江琇瑛技士發表論文簡報資料

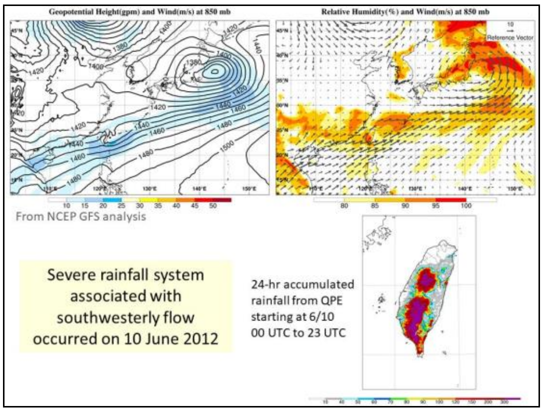


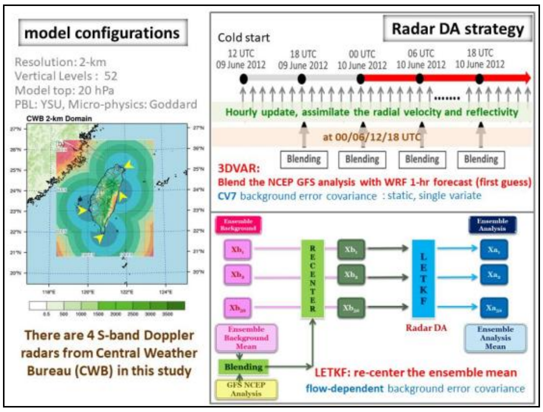


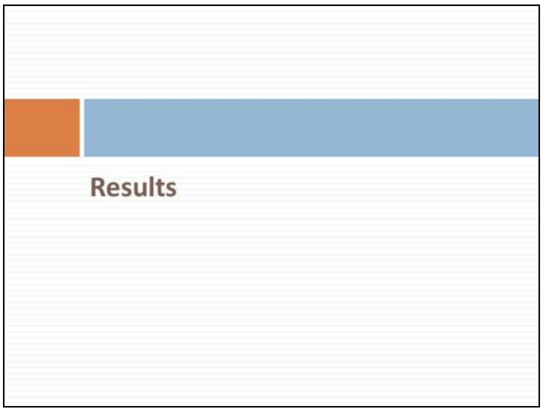


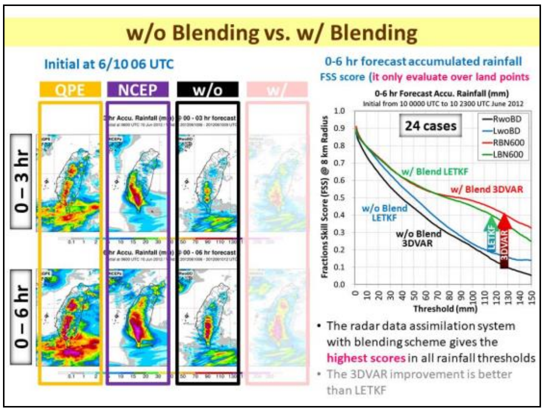


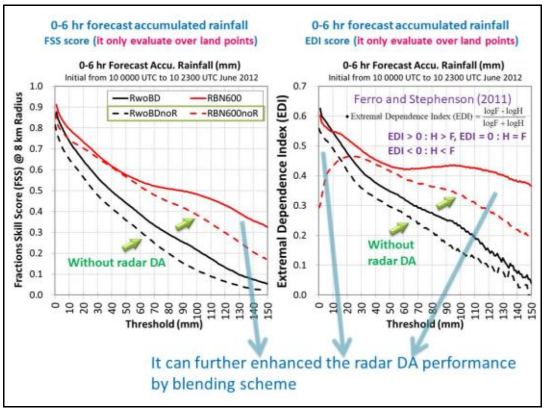


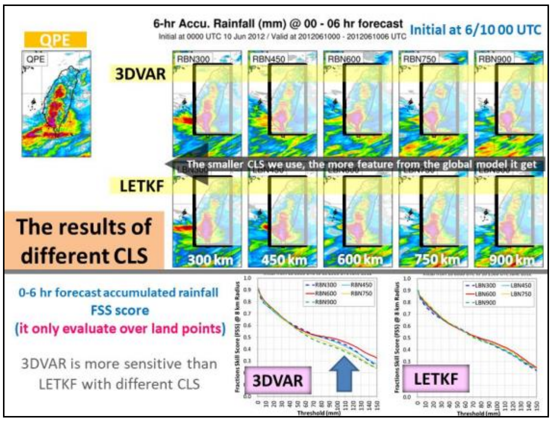


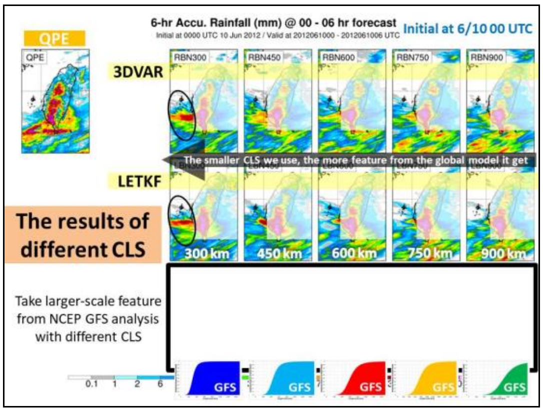


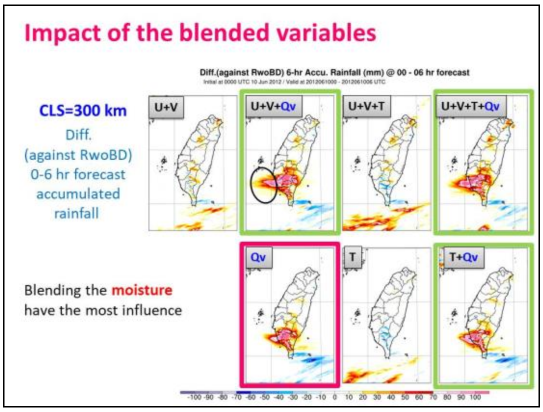


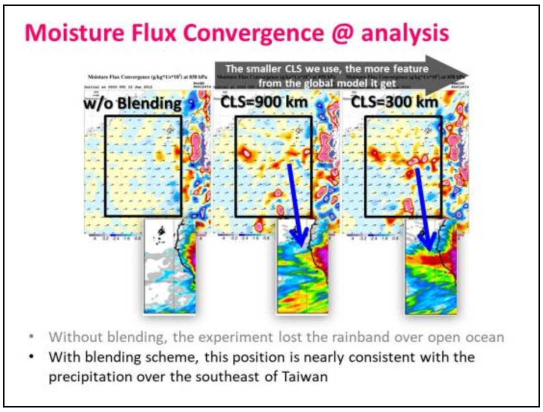












Summary

- The blending scheme is workable to reduce the accumulated model error from the continuous cycling radar data assimilation
- The model water vapor can be improved to further enhance QPF performance by the blending scheme.
- The effect of the blending scheme is different between 3DVAR and LETKF
  - The 3DVAR improvement is better than LETKF
  - 3DVAR is more sensitive than LETKF with different cut-off length scale (CLS)

The End
Thank you for listening

附錄四、李志昕技士研討會摘要

Blending of Regional Analyses and EAKF Forecasts with a Spatial Filter: Application to the Taiwan Ensemble Prediction System

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Abstract

A Weather Research and Forecast model (WRF) based ensemble prediction system (WEPS) with 20-members was operated in Taiwan Central Weather Bureau (CWB). Initial conditions of the WEPS were obtained by adding the perturbations of the Ensemble Adjustment Kalman Filter (EAKF) 6-hr forecast on the analysis of the CWB deterministic reginal forecast system. However, the spin-up was occurred due to the imbalanced initial condition from simple arithmetic combination. A multi-scale blending scheme using a low-pass spatial filter (Hsiao et al. 2015) was applied to replace the simple arithmetic combination. The blending scheme combines the deterministic analysis and the EAKF ensemble forecast field according to the specific cut-off length obtains better balanced ensemble initial condition.

In this study, experiments were conducted to exam the sensitivity of the cut-off length scale. The control run used the simple arithmetic to combine EAKF perturbation and deterministic analysis. Sensitivity experiments were designed using the blending schemes with different cut-off length of 300 km, 1200 km, 1800 km, and 2400 km respectively. The performance shows that both the RMSE and the dispersion relations using the blending scheme were improved against the control run. The experiment with 1200 km cut-off length outperformances the other experiments.

Key words: ensemble forecast, blending scheme

附錄五、李志昕技士論文全文（海報）

Blending of Regional Analyses and EAKF Forecasts with a Spatial Filter: Application to the Taiwan Ensemble Prediction System

ICMCS-XIII
6-8 March 2019
Naha, Okinawa, Japan
P140

Chih-Hsin Li, Jing-Shan Hong
Central Weather Bureau, Taiwan
Corresponding author： Chih-Hsin Li ; E-mail: cwbb679@gmail.com

1. Introduction

The goal of this study is the generation of reliable probabilistic forecasts of a WRF based ensemble prediction system (WEPS). There are 20 members with perturbations from initial condition, boundary condition and model physics. The model version was V3.8.1, and the EPS was configured as two nested domains with horizontal resolution of 15 / 3 km (Figure 1) and 52-levels in the vertical. The boundary perturbations were from the NCEP Global Ensemble Forecast System. Initial conditions were obtained by adding the perturbations of the Ensemble Adjustment Kalman Filter (EAKF ; Anderson 2001) 6-hr forecast on the analysis of the Central Weather Bureau (CWB) deterministic reginal forecast system. The initial condition is defined as :

$$IC = WRF_{ana} + (EAKF_{fst} - EAKF_{mean}) \qquad (1)$$

Where sf, ana, and fst determined the spatial filter, analysis and forecast.

However, the spin-up was occurred due to the imbalanced initial condition from simple arithmetic combination. A multi-scale blending scheme using a low-pass spatial filter (Hsiao et al. 2015) was applied to replace the simple arithmetic combination in this study. The blending scheme combines the deterministic analysis and the EAKF ensemble forecast field according to the specific cutoff length obtains more balanced ensemble initial condition.

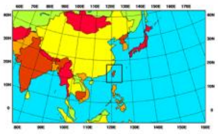

Figure 1.
The coverage of the model domains

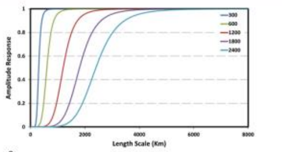

Figure 2.
Amplitude responses of a sixth-order tangent implicit filter from Raymond and Garder (1991) for cutoff lengths of 300, 600, 1200, 1800, and 2400 km, respectively.

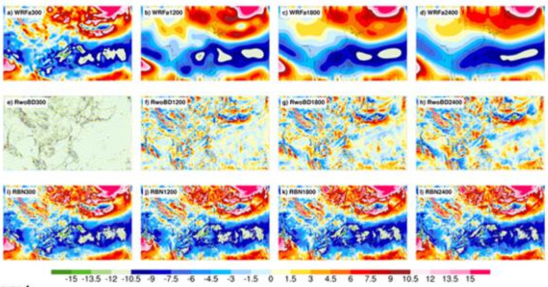

Figure 4.
The fields of U-wind after blending method with the different cutoff length scale of 300, 1200, 1800, 2400 km. (a)-(d) are the fields of WRF deterministic analysis after spatial filtering. (e)-(h) are the fields which is the difference with EAKF and EAKF after spatial filtering. (m)-(q) are the result after blending that combines the above two fields.

2. Method and experiments

The analysis by using blending scheme, which combines the large scale analysis from WRF deterministic analyses and the small-scale analysis from EAKF forecast is defined as

$$IC_{blending} = \overline{WRF_{ana}}^{sf} + \left(EAKF_{fst} - \overline{EAKF_{fst}}^{sf}\right) \qquad (2)$$

Where sf determined the spatial filter, and the sixth-order tangent implicit filter was adopted (Raymond and Garder,1991). The curve in Figure 2 shows how the EAKF forecast (left of the curve) and WRF deterministic analyses (right of the curve) were combined by blending scheme.

Experiments were conducted during the experiment period 1st December and 2nd December 2017 (4 cases) to exam the sensitivity of the cutoff length scale here. The control run (**Ctrl**) used the simple arithmetic combination to generate initial condition. And other experiments used blending scheme with cutoff length equals to 300 (**BLD300**) , 1200 (**BLD1200**), 1800 (**BLD1800**), 2400 (**BLD2400**) km cutoff length.

3. The results of synoptic forecast

The initial condition of Ctrl run (Figure 3) in 1st Dec. was more imbalance than BLD300, and that would make the forecast failed. The blending scheme can improve this problem .

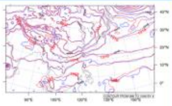

Figure 3.
The sea level pressure from the initial condition. The different experiments are denoted by line colors: Ctrl(blue), BLD300 (red)

Figure 4 shows **the larger cutoff length would get more small-scale forecast information from EAKF forecast**. Because there was only one WRF deterministic analysis, but 20 EAKF forecast were used in this study. Therefore, the experiments with larger cutoff length would get more perturbations from initial condition. Figure 5 indicates the spread would reduce by using blending scheme, and the spread of experiments with smaller cutoff length decrease more. However, the blending scheme with smaller cutoff length can improve the RMSE of ensemble mean. Although the spread decrease, meanwhile the RMSE is decrease. Hence, The performance of spread is better than Ctrl for some fields.

Score card (Figure6) shows the blending scheme with cutoff length 1200 km is the best choice, because the most of the items are better than Ctrl. However, it's the preliminary result, and more case studies are needed.

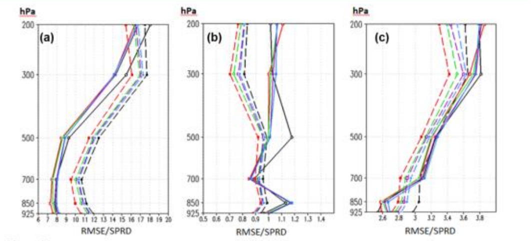

Figure 5.
Spread (dashed) and RMSE (solid) of 5 experiments over the East Asia domain for (a) geopotential height, (b) temperature and (c) zonal wind. The different experiments are denoted by line colors: control run (black), 300-km (red), 1200-km (green), 1800-km (purple), and 2400-km (blue).

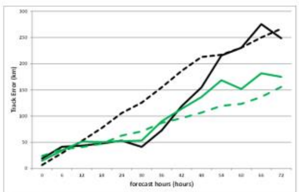

Figure 8.
Track error of the ensemble mean (solid) and spread (dashed) for four ensemble experiments as a function of lead time. The different experiments are denoted by line colors: Ctrl (black), BLD1200 (green).

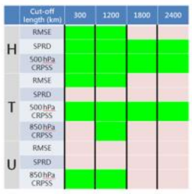

Figure 6.
Score Card. Compare with Ctrl. Green means the performance of experiments better than Ctrl, while red means it is worse.

4. The results of typhoon forecast

The performance of typhoon forecast by using blending scheme was shown in this section. Because the cutoff length 1200km would give the best performance, only Ctrl and BLD1200 were reported on the performance of two typhoon here, typhoon NESAT and typhoon NORU.

According to the typhoon track (Figure 7), some members of Ctrl are outlier, and they would make the large spread and track error. The verifications is consistence with the track. Figure 8 shows the spread of Ctrl are too large, and application of the blending scheme reduces the spread. In addition to, the track error would be improved by using blending scheme.

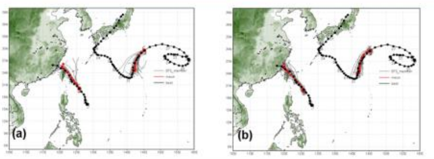

Figure 7.
Track forecast for typhoon NESAT and NORU (2017):. (a) and (b) are the forecast track of Ctrl and BLD1200 respectively. The black line is best track, red line is forecast track of ensemble mean, and gray lines are the forecast track of ensemble members.

5. The summary and Future

This research evaluates the performance and uncertainty of a WRF based ensemble prediction system (WEPS) through the blending scheme. The control run used the simple arithmetic to combine EAKF perturbation and deterministic analysis. Sensitivity experiments were designed using the blending schemes with different cutoff length of 300 km, 1200 km, 1800 km, and 2400 km respectively. The performance shows that both the RMSE and the dispersion relations using the blending scheme were improved against the control run. The experiment with 1200 km cutoff length outperformances the other experiments. However, only 4 cases were conduct here. More cases is needed to enhance the result in the near future.

6. Reference

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