

Department of Atmospheric Sciences,
National Taiwan University



Newsletter

NO.13 December 2020

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Research Highlights

- The Role of WISHE in the Rapid Intensification of Tropical Cyclones
- Recent seasonality changes in the Amazon river basin and its plume region

2020 Doctors' and Masters' Theses

Awards

- 吳俊傑教授榮聘臺灣大學講座教授（自 109 起）
- 陳正平教授榮聘臺灣大學特聘教授（109-111）
- 李清勝教授榮聘臺灣大學名譽教授
- 吳俊傑教授榮任亞洲大洋洲地球科學學會主席（109-111）
- 陳維婷副教授榮獲科技部優秀年輕學者研究計畫（109/8-112/7）
- 郭鴻基教授獲 108 學年度教學優良獎
- 洪惠敏副教授獲 108 學年度教學優良獎
- 吳健銘副教授獲 108 學年度教學優良獎
- 陳維婷老師自 109 年 8 月起升等副教授
- 黃彥婷老師自 109 年 8 月起升等副教授
- 羅敏輝副教授與國際團隊「氣候變遷下未來陸地水文循環與水資源的改變」研究，榮登《Nature Communications》期刊（109 年 7 月）
- Professor Chun-Chieh Wu received the title of the Chair Professor of NTU since 2020.
- Professor Jen-Ping Chen received the title of the Distinguished Professor (2020-2022)
- Professor Cheng-Shang Lee was named as an Emeritus Professor since 2020.
- Professor Chun-Chieh Wu was appointed as the President of AOGS(Asia Oceania Geosciences Society) (2020-2022).
- Associate Professor Wei-Ting Chen received the project of Excellent Young Scholar Research Grants by MOST (2020/8-2023/7).
- Professor Hung-Chi Kuo received the NTU Outstanding Teaching Award of 2019 Academic Year.
- Associate Professor Hui-Ming Hung received the NTU Outstanding Teaching Award of 2019 Academic Year.
- Associate Professor Chien-Ming Wu received the NTU Outstanding Teaching Award of 2019 Academic Year.
- Professor Wei-Ting Chen was promoted to Associate Professor on August 1, 2019.
- Professor Yen-Ting Huang was promoted to Associate Professor on August 1, 2019.
- The study 『Divergent effects of climate change on future groundwater availability in key mid-latitude aquifers』 by Associate Professor Min-Hui Lo was published in the 《Nature Communication》 in July, 2020.

Personnel Changes

- 李清勝教授自 109 年 2 月 1 日起退休。
- 游政谷教授自 109 年 8 月 13 日起擔任代理系主任。
- Professor Cheng-Shang Lee retired from the department since February 1st, 2020.
- Professor Cheng-Ku Yu assumed as an acting chair of the department since August 13, 2020 。

Retirement of Prof. Cheng-Shang Lee

李清勝教授於 109 年 2 月 1 日退休，本系於 109 年 1 月 3 日舉辦期末餐會暨李老師退休餐會。首先由李老師發表退休感言，接著由院長及系主任致詞及獻禮，場面溫馨感人。

Professor Cheng-Shang Lee retired from the department on February 1, 2020, and the retirement party for him was held on January 3, 2020. Prof. Lee shared his reflections in the Atmospheric Sciences Department, and the Dean of the College of Science and Chair of the Department prepared the gifts to him. It was a heartwarming farewell party for everyone.

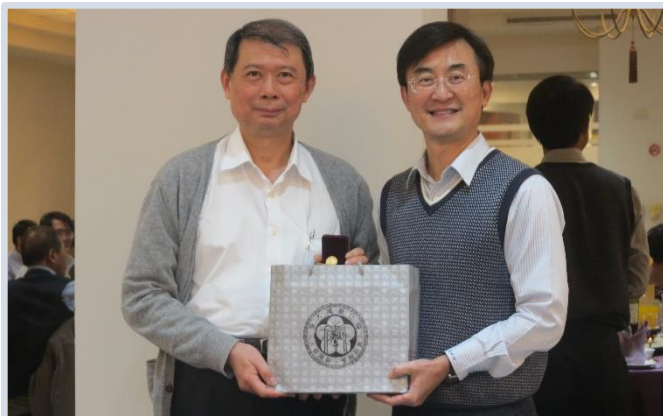


Photo for Retirement Party of Prof. Cheng-Shang Lee

NTU Azalea Festival

臺灣大學於每年3月都會舉辦為期兩天的「杜鵑花節博覽會」，提供各系所資訊給想要就讀臺大的莘莘學子，並可同時體驗各項博物展覽、藝術展演、生態資源等多元內涵的活動。今年因受新冠肺炎疫情影響，博覽會於3月14、15日改以線上互動的模式舉行；由各系所預錄招生影片；活動當天透過現場直播、臉書留言，介紹教學環境、課程、學生實驗等。

Every year around March, National Taiwan University holds the NTU Azalea Festival for two days. It is a university exhibition for high schoolers to learn more about each college in NTU as guidance to choose a major in the future. Due to the impact of COVID 19, it was held online from March 14th to 15th. The Department students prerecorded videos to welcome prospective students, and invited current students to do live streaming on the day for a Q&A session.



Commencement Ceremony

今年臺灣大學畢業典禮於 6 月 6 日早上假臺大綜合體育館舉辦，並接著於上午假凝態科學暨物理學館舉辦畢業生院長獎頒獎典禮。於 7 月 7 日下午，在系上進行撥穗典禮。「撥穗」代表稻穗成熟；由系主任及畢業班導師將畢業生帽上稻穗由右撥到左，象徵該生已學有所成，並邀請親友參與盛會。今年系上共有 38 名學士，15 名碩士及 1 名博士畢業。



NTU's commencement ceremony took place on the morning of June 6th, 2020, along with the dean's award ceremony. A hooding ceremony for the new graduates of NTUAS was held in the department on July 7, with family and friends sharing in this joyous occasion. The students graduating from NTUAS in 2020 include 38 Bachelors', 15 Masters', and 1 Doctorate degree holders.



Teacher Appreciation Party

畢業班學生於7月3日假大氣系系館舉辦謝師宴，藉此機會感謝老師在學期間的辛苦教育。活動由學生預錄短劇影片、現場播放，師生一同回顧點滴過往；再以即興表演帶動氣氛，讓畢業班與老師一同享受溫馨感人又歡笑不斷的時光。

The graduating students of NTUAS held a teacher appreciation party in the department on July 3, 2020. They prerecorded videos for teachers to look back to the past school life with students and improvised shows in this party. They thanked teachers for years of teaching, sharing and caring.



Parents Day

每年9月開學前臺灣大學會舉辦校級新生家長日。本系於9月6日舉行。本次活動由代理系主任游政谷老師主持，邀請家長們了解大氣系系況、課程及環境，進行親師生交流活動。

Every September before the new semester starts, NTU holds a Parents-teacher meeting. On September 6th, 2020, Prof. Yu, the Department Acting Chair welcomed the 1st year students and their parents to know more about the Department, the curriculum and the environment, and provided the opportunity for them to interact with the faculty and staff.



Students Awards

- 遲正祥博士獲得科技部 108 年度博士後研究人員學術著作獎。
Cheng-Hsiang Chih received the MOST Postdoctoral Research Fellow Academic Research Award in 2019 academic year.
- 葉祐瑜同學獲得科技部 108 年度大專學生研究計畫研究創作獎。
You-Yu Yeh received the MOST College Student Research Creation Award in 2019 academic year.
- 郭晏寧同學獲得科技部 108 年度大專學生研究計畫研究創作獎。
Yan-Ning Kuo received the MOST College Student Research Creation Award in 2019 academic year.
- 郭晏寧同學獲得 108 年度臺灣大學學士班學士論文獎
Yan-Ning Kuo received NTU Bachelor Degree Thesis Award in 2019 academic year.

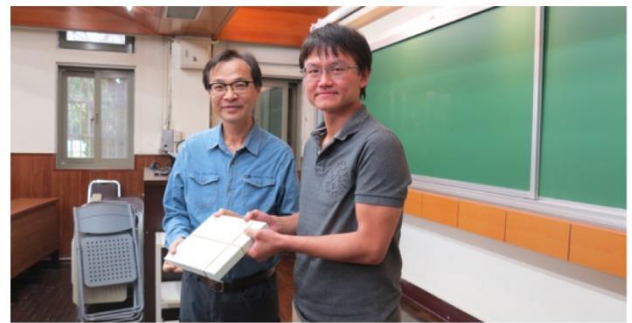
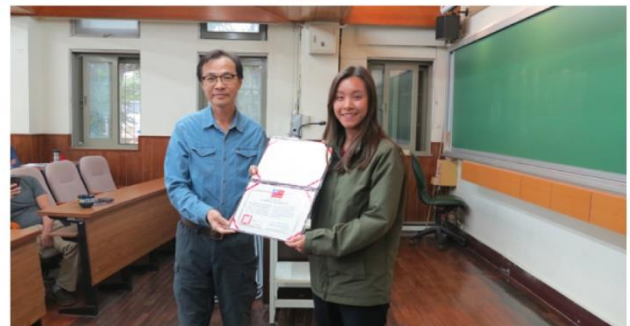
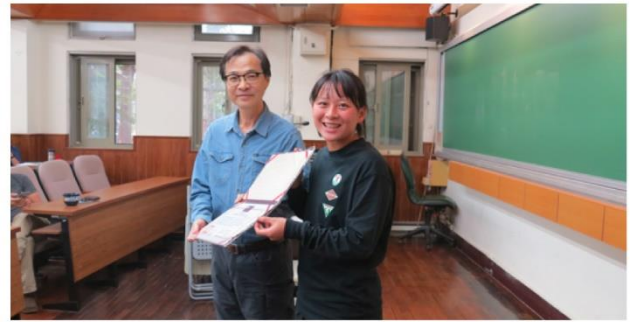


Photo for College Student Research Creation Award Winners (You-Yu Yeh, Yan-Ning Kuo) and their advisor, Prof. Min-hui Lo

郭晏寧同學得獎感言：

首先感謝羅敏輝老師、Hydroclimatology 實驗室的夥伴，針對我的研究計畫案給予許多討論與建議，讓我能更深入於我所關心的科學議題；很榮幸能夠在同一年度獲得校內學士論文獎與科技部的研究創作獎，未來期許自我能持續精進。

Message from the award winner, Yan-Ning Kuo:

First of all, I would like to thank Prof. Min-Hui Lo and the Hydroclimatology lab for helping refine my research. I am also grateful for the Ministry of Science and Technology. Thanks for supporting my project. This is such a precious experience to look into the scientific topics that I have long been interested in. I feel honored to get the awards from both the school and the Ministry. I will keep up the good work in the future.



Photo for NTU Bachelor Degree Thesis Award Winner, Yan-Ning Kuo.

2020 Undergraduate In-house Summer Research-Poster Presentation and Awards

為促進大學部學生研究能量，本系於暑假期間推行「大專生暑期研究計畫」。本次活動共計 26 位二、三年級學生分別接受 10 位系上教師指導並進行研究。活動於 9 月 11 日下午舉辦海報成果發表會，同學們彼此分享研究成果及討論交流，最終由指導教師、研究助理及研究生一同選出三名得獎者，以茲鼓勵。

To encourage undergraduate students to participate in research activities, the In-House Summer Research was run during the summer vacation. There was a total of 26 participants across the 2nd and 3rd year groups. They were under the supervision of 10 of our lecturers. These students shared their results from their research and were awarded for the best 3 poster winners by the research advisers, research assistants, and graduate students



Photo for Poster Presentation



Photo for the Winners

Their poster presentation videos can be obtained by scanning the QR Code:



Department Chair Meeting with Students

代理系主任游政谷老師分別於 11 月 26 日、12 月 11 日及 12 月 18 日與大三大四、大一大二及研究所同學舉辦系主任時間，會中除了介紹大學部課程學制及鼓勵同學及早做生涯規劃，也頒發了 108 年第二學期書卷獎給得獎同學，最後更開放同學現場發表問題及意見，並將問題及回覆處理情形置於本系網站，供師生參考。

Prof. Yu, the Department Acting Chair held the Chair meeting with students of the third and fourth year, the first and second year and the graduate students on November 26, December 11, and December 18, respectively. In addition to introducing the course requirements to university students and encouraging them to plan their career earlier, the department also awarded the scholarship to the excellent students. The meeting summary including student's questions/suggestions and the department's responses was posted on the website of the department.



Final Report (Poster Presentation) for Introduction to Atmospheric Science

本學期「大氣科學概論」於12月29日舉行期末成果報告，學生展示及講解海報內容給指導老師及同學。

The Final Report (Poster Presentation) of the class “Introduction to Atmospheric Science” was held on December 29, 2020, students presented and shared their poster with each other.

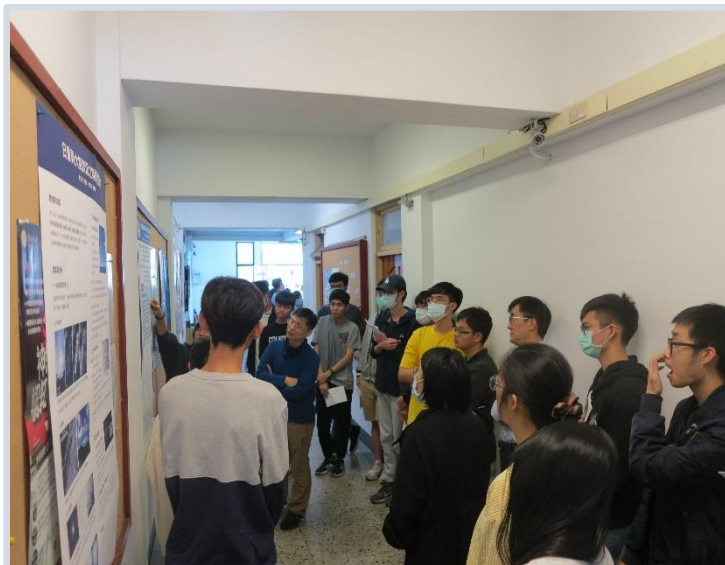


Photo for Poster Presentation

New Visiting Scholar: Dr. Christopher Moseley



Dr. Moseley is a guest scientist at the Department of Atmospheric Sciences since October 2019, with a fellowship of the German Alexander von Humboldt foundation, and funded by the Taiwanese Ministry of Science and Technology (MOST). Dr. Moseley is hosted at the research groups of Prof. Chien-Ming Wu and Prof. Wei-Ting Chen. In the past 10 years, he has mainly worked at the Max-Planck Institute for Meteorology in Hamburg Germany, in the department lead by Prof Bjorn Stevens. Dr. Moseley's main research interests are precipitating convection, extreme precipitation, and cloud resolving modeling.

Dr. Moseley has studied physics at the University of Augsburg in South Germany, with his PhD. thesis on condensed matter theory. After that, he decided to change to the field of climate science. In this new field, he first worked on regional climate modeling. He conducted and analyzed RCM simulations and climate projections and worked in teams with users of climate model data from several economic sectors, like agriculture, forestry, hydrology, coastal research, and urban water resource management. He did this work partly at the Climate Service Center Germany in Hamburg, which provides climate information to regional governments, private companies, for climate adaption purposes. During this work, he became especially interested in extreme precipitation on small spatial and temporal scales and its possible intensification in a warmer climate and has published several papers on this topic with collaborators. This topic has also a high impact on society in many parts of the world, also in Taiwan, a country that is regularly hit by heavy precipitation events caused by tropical cyclones, and thunderstorms.

In his project at the Department of Atmospheric Sciences, Dr. Moseley tries to establish a better understanding of the dynamics of large convective cluster formation, the influence of convective organization to climate sensitivity and climate change, and the conditions that lead to convective extreme precipitation events. The main study region is the North West Pacific monsoon area in general, with special focus on Taiwan. He has involved students of the Department into his research and participated in teaching activities since Spring of 2020.

Dr. Moseley is happy to discuss his work with everyone in the department/university. Please contact him using email: chrismo@as.ntu.edu.tw or at his current office (C206).

- Dr. Yi-Hsuan Chen of Department of Climate and Space Sciences and Engineering (CLaSP), the University of Michigan at Ann Arbor, USA visited the department on January 7th, 2020, and delivered a seminar titled “Influences of Surface Spectral Emissivity and Cloud Longwave Scattering on Climate Simulations”.
- Dr. Jenny Chang of Department of the Geophysical Sciences, University of Chicago visited the department on January 9th, 2020, and delivered a seminar titled “Eddy equilibration in idealized models of the extratropical troposphere”.
- Mr. Hing Ong of PhD Student, Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York visited the department on January 9th, 2020, and delivered a seminar titled “The significance of the nontraditional Coriolis terms in tropical large-scale dynamics”.
- Dr. Ya-Chien Feng of Advanced Study Program Postdoctoral Fellow, National Center for Atmospheric Research visited the department on March 24th, 2020, and delivered a seminar titled “Exploring the potential of radars to study storm processes”.
- The department of Earth Sciences of National Taiwan Normal University visited the surface observation area of the department on March 27th, 2020.



- Associate Professor Shun-Chi Wu of Department of Engineering and System Science at National Tsing Hua University visited the department on May 12th, 2020, and delivered a seminar titled “Event identification and brain functional data analysis”.
- Prof. Cheng-Ta Chen of Department of Earth Sciences, National Taiwan Normal University visited the department on May 12, 2020, and delivered a seminar titled “Human Influence on Increase of Rainfall Extremes associated with Tropical Cyclone”.
- Assistant Professor Kuan-Hui (Elaine) Lin of Graduate Institute of Environmental Education, National Taiwan Normal University visited the department on May 21, 2020, and delivered a seminar titled “Historical hydroclimate events revealed in the REACHES database”.
- Sophia Cheng, the Chief Investment Officer of Cathay Financial Holdings visited the department on June 2, 2020, and delivered a seminar titled “Responsible investment: Meaningful power for sustainability”.
- Dr. Shih-Wei Fang, Postdoc of Max Planck Institute for Meteorology visited the department on July 7, 2020, and delivered a seminar titled “Understanding ENSO Transition Complexity and its Underlying Dynamics”.
- Visiting Prof. Jian-Hun Qian, Department of Atmospheric Sciences at NTU visited the department on July 30, 2020, and delivered a seminar titled “Seasonal Evolution of Daily Weather Types and Rainfall Variability Associated with ENSO in Southeast Asia”.



- Prof. Shih-Yu (Simon) Wang of Department of Plants, Soils and Climate, Utah State University visited the department on August 24, 2020, and delivered a seminar titled “Three-way junction of forcings on a winter stationary wave: Fire and ice in North America”.

- Assistant Professor Je-Yuan Hsu of Institute of Oceanography, National Taiwan University visited the department on September 15, 2020, and delivered a seminar titled “SST Variations Modulated by Diurnal Warm Layer During the Suppressed Phase of the MJO”.



- Associate Professor Yiing-Jang Yang of Institute of Oceanography, National Taiwan University visited the department on September 15, 2020, and delivered a seminar titled “Introduction to the observation function of the Research Vessel-New Ocean researcher 1”. (新建海洋研究船的觀測功能介紹)



- Prof. Pang-Chi Hsu of Nanjing University of Information Science and Technology, China visited the department on September 22, 2020, and delivered a seminar titled “Roles of intraseasonal oscillation in the formation and subseasonal predictability of East Asian heatwave”.



- Associate Professor Chung-En Hsu of the Department of Society, National Taiwan University visited the department on September 29, 2020 and delivered a seminar titled “Climate change from the perspective of a sociologist”. (一位社會學家眼中的氣候變遷)



- Dr. Ta-Cheng Su of Department of Environmental and Occupational Medicine, National Taiwan University Hospital visited the department on October 6, 2020 and delivered a seminar titled “Air pollution and cardiovascular health: from outdoors to indoors”. (空氣污染與心血管健康：由室外到室內)



- Associate Professor Hwa Chien of The Institute of Hydrological and Oceanic Sciences, National Central University visited the department on October 27, 2020 and delivered a seminar titled “Algorithm development for sea surface wind retrieval using Triton GNSS-R and its validation strategy”.



- Associate Professor C.Y. Liu of Center for Space and Remote Sensing Research, National Central University visited the department on November 3, 2020 and delivered a seminar titled “The Role of Clouds in the Environmental Study and its Observation”.



- Dr. Yong-Ming Chen of the National Science and Technology Center for Disaster Reduction (NCDR) visited the department on November 10, 2020 and delivered a seminar titled “The Role of Clouds in the Environmental Study and its Observation”.



- Dr. Shih-Yan Lee of NCEP visited the department on November 17, 2020 and delivered a seminar titled “Satellite Instrument Calibration”.



- Prof. Jin-Yi Yu of UC-Irvine visited the department on November 26, 2020 and delivered a seminar titled “Multi-year ENSOs: Their unique dynamics, climate impacts, and El Nino-La Nina asymmetries”.



- Professor Chi-Cherng Hung of the Department of Earth and Life Science, National Taipei University visited the department on December 1, 2020, and delivered a speech titled “Understanding the fluctuation of WNP subtropical high form extreme events”.



- Assistant Research Fellow Yu-Nung Lin of Academia Sinica visited the department on December 15, 2020, and delivered a speech titled “Synthetic Aperture Radar Applications - How meteorologists can help”.
- Associate Professor Shan-Hsiang Wang of Department of Atmospheric Sciences, National Central University visited the department on December 22, 2020, and delivered the speech titled “高解析近地面大氣垂直剖面觀測”.



The Role of WISHE in the Rapid Intensification of Tropical Cyclones

WISHE 機制在颱風快速增強的角色

Chieh-Jen Cheng (鄭傑仁) and Chun-Chieh Wu (吳俊傑)

This study examines the role of surface heat fluxes, particularly in relation to the wind-induced surface heat exchange (WISHE) mechanism, in the rapid intensification (RI) of tropical cyclones (TCs). Both the thermodynamic environment and the convective-scale processes are clearly affected when capping the WISHE in the sensitivity experiments, leading to delayed RI and weaker peak intensity (Fig. 1). Before RI, the vortices are relatively weak and the convection distribution is asymmetric, caused by the environmental vertical wind shear (VWS). WISHE could help the TC to overcome some effect from the downdrafts (Fig. 2, larger upward vertical mass flux during the early time with more WISHE) and provide the convective instability after the initial environmental CAPE is consumed, resulting in more active convection and broader wind field. With stronger WISHE, TCs could intensify to a certain strength earlier, followed by further intensification.

After the early stage, earlier increase of θ_e is found in the lower level in the experiments with more WISHE (Fig. 2), which could earlier trigger the convection in the upshear quadrant. Therefore, earlier axisymmetrization of the storm vortices are found with larger upward vertical mass flux (Fig. 2). After the onset time of RI, the convection in the higher levels then becomes axisymmetric, leading to effective vortex spinup. More WISHE leads to more diabatic heating in the inner-core region and causes relatively strong inflows and efficient spinup (more diabatic heating in the region with high inertial stability). Thus, stronger peak intensity is consequently found in the experiments with more WISHE. In addition, the downward motion in the vortex center is also more active with more WISHE, leading to stronger warm core and lower minimum sea level pressure in TC center. To sum up, WISHE could affect the TC evolution both in the pre-RI stage (in a stage where the TC starts to gradually intensify) and during the RI stage.

海表面熱量通量為颱風發展的重要能量來源之一，而本研究探討了與海表面熱量通量相關之 WISHE 機制在颱風快速增強時的角色。分析指出，限制 WISHE 機制將影響到颱風的熱力環境與對流的相關過程，並導致較弱的颱風巔峰強度與延遲快速增強開始時間(圖 1)。在颱風快速增強開始之前，渦旋結構較弱，同時對流的分布也因環境風切的影響而較不對稱。在環境初始的對流可用位能被消耗後，WISHE 可提供對流不穩定度，並導致較強且較活躍的對流與較大的風場；同時，也能抵銷較多下衝流的影響(圖 2，較強 WISHE 的實驗整體具有較強的向上值量通量)。具有較強 WISHE 的實驗更早達到一定強度繼續發展。

在初始階段後，較強的 WISHE 機制造成大氣低層相當位溫的增加(圖 2)，並使位於颱風上風切象限的對流得以發展，導致較為軸對稱的對流結構，以及較大的垂直質量通量(圖 2)，促使颱風快速增強的發生。在颱風快速增強的階段，颱風中至高對流層的對流將逐漸軸對稱化，並透過對流所提供的非絕熱加熱，颱風將更有效率的增強。比較各實驗之後發現，較強的 WISHE 機制將因為有較強的內核對流而產生較多的非絕熱加熱，進一步導致相對較強的內流與較有效率的加熱(非絕熱加熱於慣性穩定度較高的內核區域)。因此，颱風的最大強度將因為 WISHE 機制的強弱而改變。

同時，內核對流的強弱也會影響颱風中心的下沉運動並經由颱風中心中高層的暖心強弱與海表面的最低氣壓反映。總而言之，WISHE 機制將影響颱風的快速增強時間以及增強的幅度，並且在颱風啟動快速增強的前後皆有其影響力。

Citation: Cheng, C.-J., and C.-C. Wu, 2020: The Role of WISHE in the Rapid Intensification of Tropical Cyclones. *J. Atmos. Sci.*, 77, 3139–3160, <https://doi.org/10.1175/JAS-D-20-0006.1>.

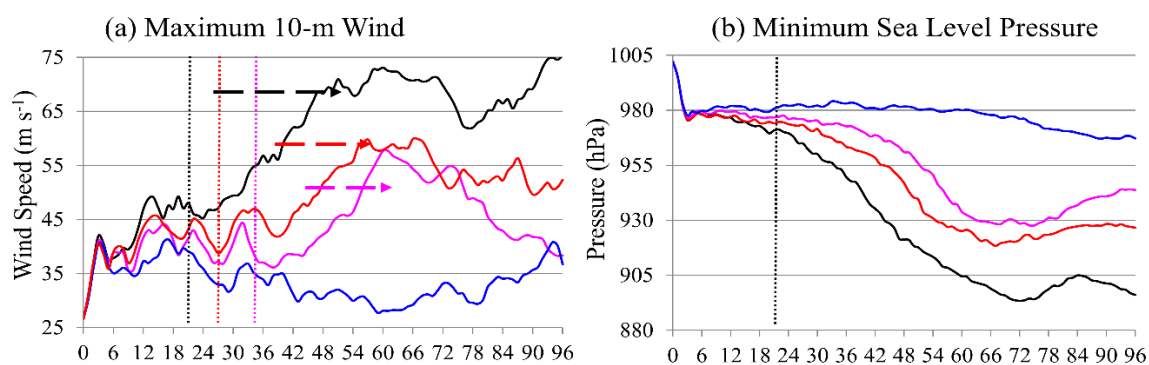


Figure 1. (a) The maximum 10-m wind speed (m s^{-1}) of each experiment (black: CTL, blue: CAP-10, magenta: CAP-15, red: CAP-20). The dotted lines (black: CTL, red: CAP-20, and magenta: CAP-15) indicate the RI onset time defined by the increase of maximum 10-m wind speed. The dashed arrows indicate the significantly intensifying period (black: CTL, red: CAP-20, and magenta: CAP-15). (b) The minimum sea level pressure (hPa) of each experiment. The dotted line (black: CTL) indicates the RI onset time defined by the change of minimum sea level pressure.

圖 1 (a) 颱風的最大 10 公尺高風速隨時間的演變，黑色、藍色、桃紅色與紅色分別為：CTL、CAP-10、CAP-15 與 CAP-20 實驗。實驗名稱中的數字代表在計算海表面熱量通量時，所使用風速的上限值，當颱風海表面實際風速大於這個數值時，則使用這個數值計算海表面的可感熱與潛熱通量。因此，數字越小，代表颱風可以獲得的最大海表面熱量通量越小，WISHE 機制的限制也越嚴格。圖上垂直的虛線為各實驗開始快速增強的時間(CAP-10 無)，箭頭代表顯著發展時期，其定義為颱風在此階段中每 6 小時表面最大風的增強幅度皆大於 3.85 公尺/每秒。本圖中，快速增強的定義是颱風位於 10 公尺的最大風，在一天之內增強超過 15 公尺/每秒。(b) 颱風的中心最低氣壓隨時間的發展。黑色的垂直虛線為 CTL 開始快速增強的時間。本圖中，颱風快速增強使用中心最低氣壓的發展來定義。當颱風的中心最低氣壓在一天內下降超過 42 百帕，則定義為快速增強。

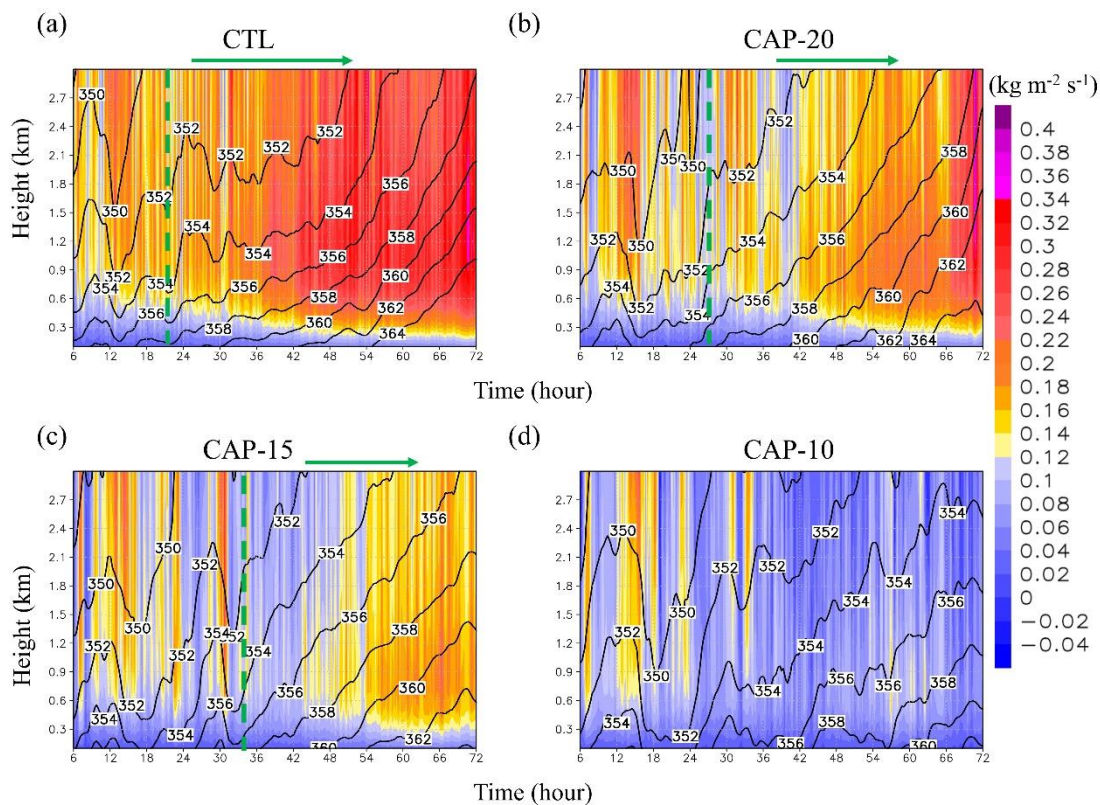


Figure 2. (a)–(d) Evolutions of the area-averaged (from 0 to 80-km radius) equivalent potential temperature (contour, K) and vertical mass flux (shaded, $\text{kg m}^{-2} \text{s}^{-1}$). (a) CTL, (b) CAP-20, (c) CAP-15, and (d) CAP-10. In each panel, the straight dashed line indicates the onset time of RI period, and the green arrow indicates the significantly intensifying period.

圖 2 (a) – (d) 颱風內核區(距颱風中心半徑 80 公里內)中不同高度上, 相當位溫(等值線)與垂直的質量通量(著色區域)之軸對成區域平均隨時間之演變。垂直的綠色線條為各實驗快速增強的起始時間, 水平的箭頭則為各實驗顯著發展時期。

Recent seasonality changes in the Amazon river basin and its plume region**過去四十年亞馬遜河流域的季節性增強及其對鄰近海洋鹽度的影響****Yu-Chiao Liang; Chia-Wei Lan; Min-Hui Lo****梁禹喬、藍嘉偉、羅敏輝**

The Amazon river basin is an essential hydrological component in South America, which receives about 2000 millimeter annual rainfall and contributes about 17% of global river freshwater input to the oceans. This international cooperation research led by the Department of Atmospheric Sciences, College of Science, National Taiwan University, examines the seasonality change of Amazon river discharge in the past decades and its impacts on the neighboring ocean salinity. International cooperators include scientists from the Woods Hole Oceanographic Institution and the National Center for Atmospheric Research. This study is published online in Nature Communications in September 2020.

Hydroclimatic variations of the Amazon river basin can profoundly impact the marine ecosystem in the Amazon plume region and have potential far-reaching influences on hydroclimate over the tropical Atlantic. This study finds that an amplified seasonal cycle of Amazonia precipitation in the past four decades enhanced seasonalities in both Amazon river discharge and ocean salinity in the Amazon plume region. Researchers use well-designed hierarchical global climate model experiments to quantify the relationships of these enhanced seasonalities found in observational records. The results suggest that an intensified hydroclimatological cycle may develop in the Amazonia atmosphere-land-ocean coupled system, favouring more extreme terrestrial and marine conditions.

Previous studies mainly focused on the specific dry or wet seasons without considering the seasonality changes in a comprehensive fashion. Our results provide a new route to further study the Amazonia hydroclimatology and the occurrence of extreme events in the Amazon river basin and Amazon plume region.

亞馬遜河流域在南美洲水循環研究扮演舉足輕重的角色，每年熱帶大氣對流為亞馬遜河流域帶來充沛的降水（約 2000 毫米），而大部分淡水流入赤道大西洋且顯著地影響當地的水循環結構及鄰近海洋生態系統。過去研究大都只關注於亞馬遜河流量單純在乾季或濕季的變化，本研究提出新的研究觀點——流量乾濕季差距（季節差距）——來探討亞馬遜河流量的改變及其對鄰近海洋所造成的影響。

首先，本研究利用觀測資料發現亞馬遜河流量的季節差距在過去四十年有不斷增強的趨勢，此差距增強是由於乾季河流流量變少，加上濕季河流流量變多所導致，近一步的分析發現河流季節差距的改變主要是因為當地乾濕季降水差距增大所導致。河流流量季節差距增大的同時也導致了鄰近海洋鹽度季節差距變大。以上分析觀測資料的大氣降水-陸地河流流量-海洋鹽度的關係並藉由全球模式數值實驗驗證，並用以加強解釋其物理機制。本論文結果闡釋了未來亞馬遜河流域的水循環過程會持續增強及導致更多陸地與海洋極端現象的發生。

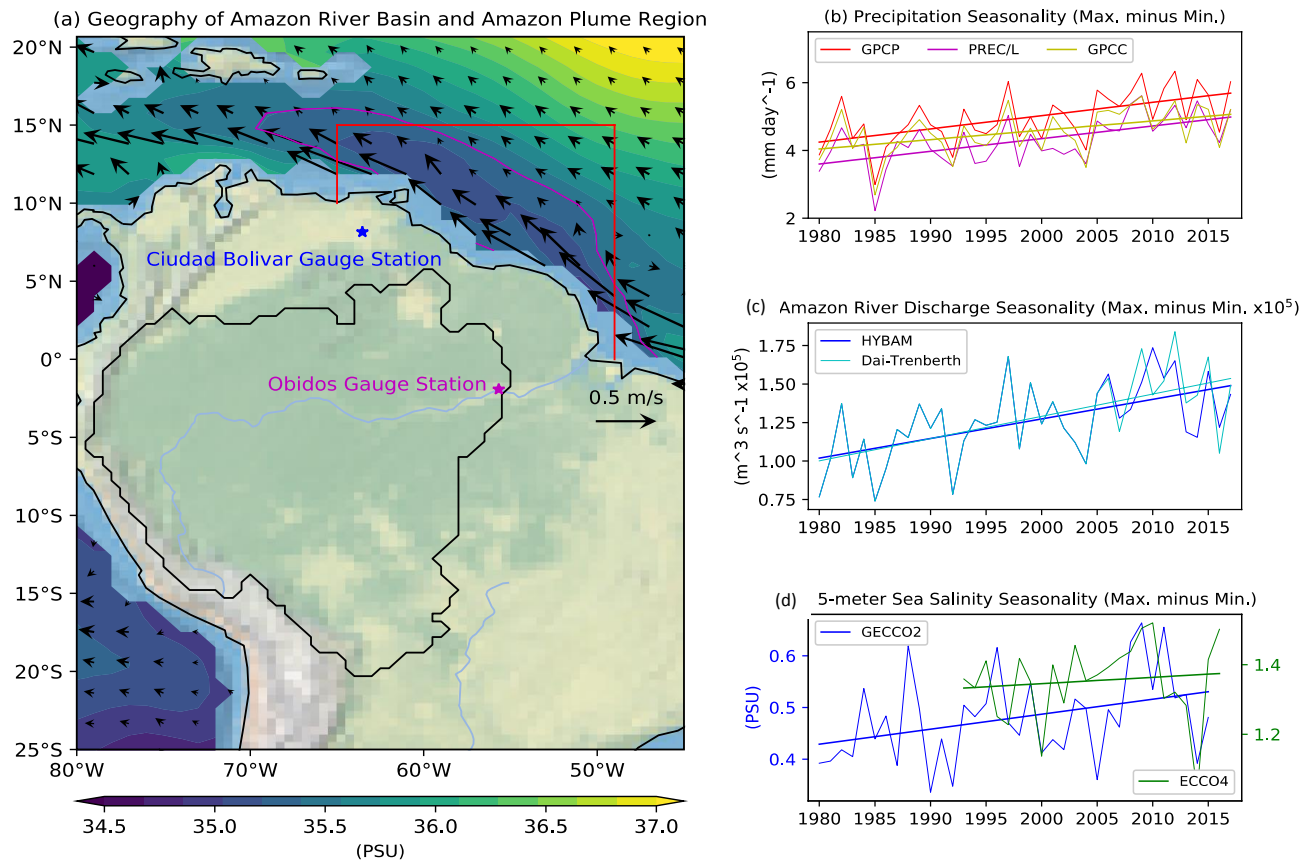


Figure 1. Relationships between the seasonal cycles in Amazonia precipitation, Amazon river discharge, and ocean salinity in the Amazon plume region. a, The geographic domain of Amazon river basin (black contour line) and Amazon plume region (red box). The colour shading over the ocean represents annual mean 5-meter ocean salinity with 34.5 PSU countoured as magenta, and the black arrows denote annual mean 5-meter ocean current velocities. The magenta and blue stars denote the location of the Obidos and Ciudad Bolivar gauge stations, where Amazon and Orinoco river discharges were recorded respectively. b, The seasonality of Amazonia precipitation (maximum minus minimum values) during the period 1979–2018. c–d, are similar to b but for Amazon river discharge and ocean salinity in the Amazon plume region respectively.

圖 1. 亞馬遜河流域大氣降水，河流流量，以及鄰近海洋鹽度的季節性關聯與變化。a. 亞馬遜河流域地理位置示意圖。黑色線表示亞馬遜河流域，暗紅色星號表示 Obidos 河流流量測站位置。紅色線表示本研究關注的海洋區域，海洋區域中顏色表示長期海表面鹽度的平均值，箭頭向量則表示平均海洋洋流的方向及強度。b. 亞馬遜河流域大氣降水的季節性在過去四十年的變化，季節性的定義為一年內流量最大值減去最小值。c–d 跟 b 類似不過表示亞馬遜河流域流量以海洋鹽度的季節性變化。

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