探索氣候變幻中的極端天氣：美國海軍官校科學及工業研討會與會經驗

Exploring Extreme Weather in a Changing Climate Experience at The U.S. Naval Academy Science and Engineering Conference

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Yvette M. Davids中將和所有參與會議的國際學生合照

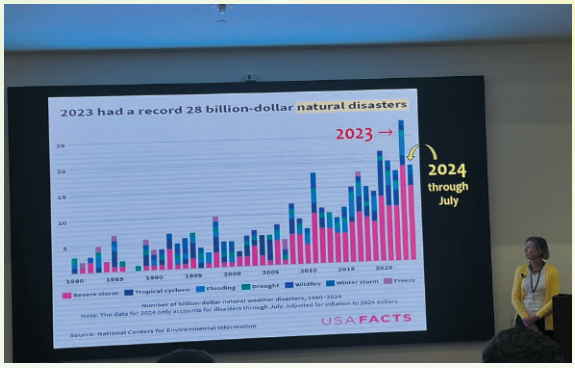
美國海軍官校科學與工程會議（Naval Academy Science and Engineering Conference, NASEC）是一場每年一度的高階學術與技術論壇，很榮幸這次能代表海軍官校參與此次會議，過程分為兩個部分，其一為專題演講，透過專家的分享為我們解說極端氣候變化所帶來的影響，探討如何避免極端氣候的發生以及運用科技的力量解決現代氣候變遷的問題，此外，各國代表及該校學生可於提問時間與該講者進行更深入的主題探討。其二為團體討論及海報展示，NASEC 的核心不僅在於提供學術交流的機會，還致力於促進跨領域的思維碰撞，團體討論中每個來自世界各地的學者做腦力激盪，發表自己不同的想法，且透過開放式的討論，讓大家能在合作中更加認識彼此。第三天的海報展示是來自世界各國的大專生或軍事院校學生展示自身研究的成果，也藉由該活動的進行，激發出許多對於自身研究的靈感；透過參加本次活動使我們受益良多，除平日參與會議中所習得之專業知識，日常生活中，我們也藉由與美國海軍官校學生的相處中觀察他們的生活模式，發現文化上的差異，另外在參與過程中結交各國朋友，這些跨國的連結不僅拓展了視野，更是一次拓展自我的旅程，使自我對於思想和情感上更加開放、包容與豐富，對於未來的個人發展和人際關係產生長遠的正面影響。

The United States Naval Academy Science and Engineering Conference（hereinafter referred to as the NASEC）. This is an annual high-level academic and technical conference, and I am honored to represent the R.O.C.Naval Academy at this conference. The event is divided into two parts. The first part consists of keynote speeches, where experts share their insights on the impacts of extreme climate change, discuss ways to prevent extreme climate events, and explore how to leverage technology to address modern climate change issues. In addition, representatives from various countries and students from the academy have the opportunity to engage in deeper discussions with the speakers during the Q&A sessions.

The second part involves group discussions and poster presentations. The core of NASEC is not only to provide

opportunities for academic exchange but also to foster interdisciplinary thinking. During group discussions, scholars from around the world engage in brainstorming sessions, sharing diverse perspectives. Through open discussions, participants get to know each other better and collaborate effectively. On the third day, the poster session featured students from universities and military academies worldwide, showcasing the results of their research. This event also sparked many new ideas for their own research.

By participating in this event, we have gained a lot. In addition to the professional knowledge we acquired during the conference, in our daily lives, we also had the chance to observe the lifestyles of the students from the U.S. Naval Academy, which allowed us to notice cultural differences. Moreover, throughout the process, we made friends from different countries. These international connections not only expanded our horizons but also served as a journey of personal growth, making us more open, tolerant, and enriched in both our thinking and emotions. These experiences will have a long-lasting positive impact on our personal development and interpersonal relationships in the future.



壹、主題和專題講演（Themes and Keynote Speeches）

（一）熱帶氣旋與海洋交互作用

演講中重點專注於了解海洋的混合層動力學，特別是在熱帶地區的影響，對於海洋溫度和鹽度分層對熱帶氣旋增強的影響有了深入的了解，也提到透過在熱帶大西洋佈設觀測浮標網絡，科學家可以更有效地追踪海洋和大氣之間的能量傳遞，這對於改善颶風的預報至關重要。熱帶氣旋是複雜的天氣系統，而海洋溫度和鹽度的變化在其增強過程中扮演了重要角色。當海水溫度上升並與氣旋的低壓系統相遇時，氣旋可能會快速增強。反之，當鹽度增加導致海水密度增大，會限制颶風的增強。這些現象都可以透過 PIRATA 和 Saildrone 等項目進行觀測。再與 NOAA 的作業中心密切合作，將研究成果轉化為實際應用，這不僅提升了天氣和氣候的預報能力，也增強了對熱帶氣候變異的理解。此外，Saildrone 項目中使用的無人船搭載多種傳感器，能夠深入颶風中心收集實測數據，這樣的技術突破，讓氣象學家能夠更準確地了解氣旋結構和其增強機制。全球氣候變化增加了極端天氣事件的頻率和強度，這些項目的數據不僅可以改善颶風預測，還有助於理解氣候變遷對熱帶氣旋活動的影響。這些研究為政策制定者提供了關鍵的科學依據，幫助社會更好地準備應對氣候變遷帶來的挑戰，並且讓我們對熱帶氣旋和海洋的動態有了更清晰的認識，不僅對於颶風預測至關重要，亦對全球氣候變化的應對產生深遠影響。

（二）科學研究與實際應用的結合

主要圍繞 NOAA 氣象預測中心在天氣預報和極端天氣應對方面的重要角色，並強調科學研究與實際應用的緊密結合。演講者 Dr. David Novak 作為 NOAA 氣象預測中心主任，領導團隊專注於降雨、冬季風暴、極端氣溫等極端天氣的預報，並致力於整合全國各地的天氣數據，以提供宏觀的氣象資訊。氣象預測中心在各類極端天氣事件中扮演至關重要的角色，例如颶風、暴風雪和洪水等，氣象預測中心通過整合當地的氣象數據，分析天氣趨勢，並提供專業預報和應對建議，為公共安全提供保障，並強調準確的天氣預測不僅依賴於數據和技術，也依賴於各部門的協同合作。在極端天氣事件中，氣象預測中心通過快速傳遞關鍵的預報資訊給地方氣象部門和政府機構，以便迅速採取應對行動，

例如疏散或加強防洪設施。另一個核心理念是將新興的科學技術轉化為操作性的應用。透過將最新的研究成果和科學技術應用於日常預測和風險管理，預測準確性可以大幅提高。隨著氣候變遷帶來的極端天氣頻率增加，這種技術轉化顯得更加迫切。以冬季風暴的預測為例，指出科學家如何運用改良的數值預報模型來分析大氣中的冷暖交互作用，進而準確預測降雪範圍和強度，這有助於交通部門提早準備道路清理工作，減少對交通和居民的影響。

總的來說，通過前沿科學、跨部門協作和技術創新來應對極端天氣，並通過將新興科學與實際操作結合，氣象預測中心不僅提升了預測能力，也強化了全國的災害應變能力。

（三）如何透過地區行動來提升氣候變遷意識

演講者 Dr. Michelle Hawkins 作為 NASA 氣候韌性與社區行動計劃的經理，強調社區在應對氣候變遷過程中的核心角色。氣候變遷不僅僅是一個全球性的科學問題，更是一項需要主動參與的社會責任，因此，結合科學研究和地區需求是創建一個能促進科學和行動的橋樑。進一步說明 NASA 如何利用衛星和氣象數據來監測全球氣候變化，並將數據應用於各地社區的氣候韌性計劃中。NASA 收集的數據不僅為全球氣候模型提供支持，還幫助各地社區評估當地的風險，比如海平面上升、極端天氣頻發的地區，以及乾旱和水資源短缺等問題。透過將這些數據分享給地方政府和非政府組織，NASA 幫助社區更好地理解氣候變遷對他們生活的實際影響，並制定針對性的應對措施。例如，在容易受到洪水威脅的地區，NASA 提供的數據可以協助政府規劃更適合的排水系統或加強河道防護設施。在演講中，提到如何將不同機構的資源和專長整合在一起，從而支持社區應對氣候挑戰。例如，她與住房部合作，幫助規劃可承受極端氣候的建築物和基礎設施，並與 NOAA 合作分析氣候變化趨勢，從而協助決策者制定政策。總結來說，透過在 NASA 和其他機構的跨部門協作，幫助社區和政策制定者在面對氣候變遷時擁有更好的應對工具和策略，並強調了科學應用於社會的重要性，並展示了如何將科技轉化為實際行動，從而幫助各地社區更好地適應未來的氣候挑戰。

（四）氣候變遷與人類活動之間的相互影響

演講中演講者 Dr. Calvin 強調了數據和模型在氣候研究中的重要性。這些模型可以分析人口增長、資源匱乏以及氣候變遷對人類社會的長期影響，並讓科學家預測氣候變化的趨勢並制定應對方案，以便在資源稀缺或生態系統脆弱的地區實施更具針對性的保護措施。氣候變遷與人口增長之間的挑戰，隨著人口增長和資源需求的增加，人類的活動正在對氣候和環境造成愈加明顯的壓力。為了幫助全球適應這些變化。演講還特別提到教育和科學傳播的關係，通過與不同受眾群體交流，例如學校、社區組織和政府機構，科學家可以讓大眾更好地理解數據背後的意義，從而促進人們在日常生活中採取行動應對氣候變遷。此外，在透過建立複雜的數據模型，揭示了人類活動與氣候系統的密切關聯，並強調了跨部門合作和公共科學教育在氣候應對中的關鍵作用，這些不僅讓人們對全球氣候問題有了更深入的理解，也為應對未來的環境挑戰提供了指引。

（五）北極快速變遷對全球氣候的影響

北極的氣溫變化速度比地球其他地區更快，這種現象稱為「極地放大效應」，它不僅改變了當地的生態環境，還對全球氣候系統產生深遠影響。隨著北極的變暖，北極海冰融化與噴射氣流之間的關係更為顯著，冰雪覆蓋的減少降低了地表反射率，使得更多的太陽能量被吸收，進一步加劇了北極變暖。這種變化對高空的噴射氣流造成擾動，使其變得更加曲折和緩慢，導致冷暖空氣在北半球移動的速度和方向異常。這種氣流改變加劇了極端天氣的頻發性，如長時間的乾旱、高溫和暴風雪等。而這些北極變遷現象與極端天氣事件的增加息息相關。例如，北美和歐洲經歷的長時間熱浪、暴雨和寒潮等異常天氣，都可能與北極變暖造成的噴射氣流變化有關。這些氣候模式的改變增加了天氣系統的「黏滯性」，使得極端天氣持續的時間更長，影響的範圍更廣。這不僅給農業、經濟和人類健康帶來巨大挑戰，也增強了人類應對氣候變遷的迫切性。北極的變遷是全球氣候系統中相對新的現象，科學家仍在努力理解其動力學和對其他地區的潛在影響。隨著觀測技術的進步，研究人員可以更深入地追踪北極變遷的具體細節，例如海冰的厚度變化、溫度上升的幅度和降水模式的改變，這些都為理解氣候變遷提供了重要數據支持。這可讓人們更深刻地認識到北極變遷對全球氣候的威脅，北極的暖化不僅僅是一個區域性問

題，更是一個攸關全球氣候穩定的關鍵因素，並警示各界對氣候變遷的重視與應對，為應對未來的環境挑戰提供了清晰的方向。

（六）氣候行動、環境永續性以及多元化工作環境的重要使命

演講者 Dr. Rick Spinrad 的演講集中探討了 NOAA（美國國家海洋暨大氣總署）在氣候行動、環境永續性以及多元化工作環境中的重要使命，特別是在極端天氣事件頻發的情況下，NOAA 的科學研究和觀測計畫成為幫助政府、企業和社區預測和應對氣候變遷的重要資源，並呼籲各國共同採取行動，減少溫室氣體排放，以緩解氣候危機。在環境永續性方面，提到 NOAA 的研究不僅著眼於氣候監測，還涵蓋了海洋保護、可持續漁業和污染減少等範疇。海洋是人類糧食、能源和文化的資源來源，因此，必須加強保護措施，確保資源的永續利用，從而保障未來世代的生活品質，而來自不同背景的科學家和技術人員合作，可以帶來多樣化的視角，更有效地解決氣候與環境挑戰。

(1) Interaction between Tropical Cyclones and the Ocean

The lecture focused on understanding the dynamics of the ocean's mixed layer, particularly in tropical regions, and provided an in-depth understanding of how temperature and salinity stratification in the ocean affects the intensification of tropical cyclones. It was also mentioned that by deploying observation buoy networks in the tropical Atlantic, scientists can more effectively track the energy transfer between the ocean and the atmosphere, which is crucial for improving hurricane forecasting. Tropical cyclones are complex weather systems, and changes in ocean temperature and salinity play an important role in their intensification process. When sea surface temperatures rise and encounter the low-pressure system of a cyclone, the cyclone can intensify rapidly. Conversely, when an increase in salinity raises seawater density, it limits hurricane intensification. These phenomena can be observed through projects such as PIRATA and

Saildrone. Close cooperation with NOAA's operational centers allows research findings to be applied in practice, which not only improves weather and climate forecasting capabilities but also enhances our understanding of tropical climate variability. Additionally, the Saildrone project uses unmanned boats equipped with various sensors that can collect real-time data deep within the center of a hurricane. This technological breakthrough enables meteorologists to better understand the structure of cyclones and their intensification mechanisms. Global climate change has increased the frequency and intensity of extreme weather events, and the data from these projects not only improves hurricane forecasting but also helps to understand the impact of climate change on tropical cyclone activity. This research provides policymakers with crucial scientific data to help society better prepare for the challenges brought by climate change, and it gives us a clearer understanding of the dynamics between tropical cyclones and the ocean. This is vital not only for hurricane forecasting but also for addressing global climate change.

(2) Integration of Scientific Research and Practical Applications

The focus of the presentation was on the crucial role of the NOAA Weather Prediction Center in weather forecasting and responding to extreme weather events, emphasizing the close integration of scientific research with practical applications. Dr. David Novak, the Director of the NOAA Weather Prediction Center, leads a team focused on forecasting extreme weather events such as rainfall, winter storms, and extreme temperatures, and is dedicated to integrating weather data from across the country to provide comprehensive meteorological information. The center plays a vital role in forecasting various extreme weather events, such as hurricanes, blizzards, and floods. By integrating local weather data and analyzing weather trends, the center provides professional forecasts and response recommendations to

ensure public safety. Accurate weather forecasting, as highlighted in the presentation, relies not only on data and technology but also on collaboration across departments.

During extreme weather events, the Weather Prediction Center rapidly transmits critical forecast information to local meteorological departments and government agencies so they can take swift action, such as evacuations or reinforcing flood control infrastructure. Another key concept is the translation of emerging scientific technologies into operational applications. By applying the latest research findings and scientific advancements to daily forecasting and risk management, the accuracy of predictions can be significantly improved. With the increasing frequency of extreme weather events driven by climate change, the need for this technological translation has become even more urgent. For example, in winter storm forecasting, scientists use enhanced numerical prediction models to analyze the interactions of cold and warm air masses in the atmosphere, accurately predicting snowfall extent and intensity. This helps transportation departments prepare for road clearing in advance, minimizing the impact on traffic and residents.

In summary, by combining cutting-edge science, interdepartmental collaboration, and technological innovation to respond to extreme weather, and by integrating emerging scientific developments with practical operations, the Weather Prediction Center has not only enhanced its forecasting capabilities but also strengthened the nation's disaster response ability.

(3) Enhancing Climate Change Awareness through Regional Actions

Dr. Michelle Hawkins, the Manager of NASA's Climate Resilience and Community Action Program, emphasized the central role of communities in addressing climate change. Climate change is not only a global scientific issue but also a social responsibility that requires active participation.

Therefore, combining scientific research with regional needs creates a bridge that fosters both science and action. Dr. Hawkins further explained how NASA uses satellite and meteorological data to monitor global climate change and applies this data to community climate resilience plans around the world. The data collected by NASA not only supports global climate models but also helps communities assess local risks, such as sea-level rise, frequent extreme weather events, droughts, and water scarcity.

By sharing these data with local governments and non-governmental organizations, NASA helps communities better understand the practical impacts of climate change on their lives and develop targeted response strategies. For example, in areas threatened by flooding, the data provided by NASA can assist governments in planning better drainage systems or reinforcing river defenses. The lecture also highlighted how different organizations' resources and expertise can be integrated to support communities in tackling climate challenges. For instance, Dr. Hawkins collaborated with the Department of Housing to plan buildings and infrastructure that can withstand extreme weather and worked with NOAA to analyze climate change trends, helping decision-makers formulate policies.

In summary, through inter-agency collaboration between NASA and other organizations, communities and policymakers are provided with better tools and strategies to respond to climate change. This also underscores the importance of applying science to society and demonstrates how technology can be translated into practical actions to help communities better adapt to future climate challenges.

(4) The Interplay between Climate Change and Human Activities

In his presentation, Dr. Calvin emphasized the importance of data and models in climate research. These models analyze the long-term impacts of population growth, resource scarcity, and climate change on human society, allowing scientists to predict climate

change trends and develop response strategies. This helps implement more targeted conservation measures in areas with limited resources or fragile ecosystems. The challenges between climate change and population growth have become increasingly apparent as human activities exert greater pressure on the climate and environment due to rising population and resource demands.

The lecture also highlighted the relationship between education and scientific communication. By engaging with various audiences, such as schools, community organizations, and government agencies, scientists can help the public better understand the meaning behind the data, thereby encouraging individuals to take action in their daily lives to address climate change. Additionally, through the creation of complex data models, the close connection between human activities and the climate system was revealed, underscoring the key role of interdepartmental collaboration and public science education in climate response. These efforts not only deepen public understanding of global climate issues but also provide guidance for addressing future environmental challenges.

(5) The Rapid Arctic Changes and the Impact on Global Climate

The Arctic is warming at a rate faster than other regions of the Earth, a phenomenon known as the "Arctic Amplification Effect." This not only alters the local ecosystem but also has profound implications for the global climate system. As the Arctic warms, the relationship between Arctic sea ice melt and the jet stream becomes more pronounced. The reduction in snow and ice coverage lowers the surface albedo, meaning more solar energy is absorbed, which further intensifies Arctic warming. This change disrupts the high-altitude jet stream, making it more wavy and sluggish, causing abnormal movements of cold and warm air in the Northern Hemisphere.

This alteration in jet stream behavior exacerbates the frequency of extreme

weather events, such as prolonged droughts, heatwaves, and blizzards. These Arctic changes are closely linked to the increase in extreme weather events. For example, prolonged heatwaves, heavy rains, and cold spells experienced in North America and Europe may be associated with changes in the jet stream caused by Arctic warming. The shifting climate patterns increase the "stickiness" of weather systems, making extreme weather last longer and affecting broader regions. This poses significant challenges to agriculture, the economy, and human health, highlighting the urgency for humanity to respond to climate change.

The changes in the Arctic represent a relatively new phenomenon in the global climate system, and scientists are still working to understand its dynamics and potential impacts on other regions. With advancements in observation technologies, researchers are now able to track the specific details of Arctic changes, such as variations in sea ice thickness, temperature rise, and changes in precipitation patterns. These provide crucial data to support our understanding of climate change. This deepens our recognition of the threat Arctic changes pose to global climate stability. The warming of the Arctic is not just a regional issue; it is a critical factor affecting global climate stability. It serves as a warning for all sectors to pay greater attention to and act on climate change, offering a clear direction for addressing future environmental challenges.

(6) The Important Mission of Climate Action, Environmental Sustainability, and a Diverse Work Environment

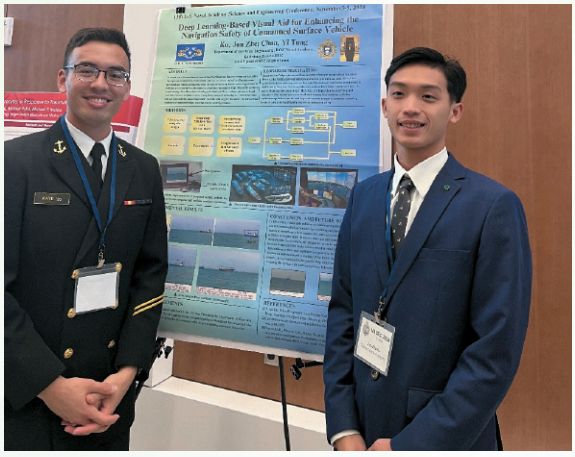
In his presentation, Dr. Rick Spinrad focused on the key missions of NOAA (National Oceanic and Atmospheric Administration) in climate action, environmental sustainability, and fostering a diverse work environment. Particularly in the context of frequent extreme weather events, NOAA's scientific research and observational programs have become vital resources to help governments, businesses, and communities forecast and respond to climate change. He called on nations

to take collective action to reduce greenhouse gas emissions to mitigate the climate crisis.

Regarding environmental sustainability, Dr. Spinrad emphasized that NOAA's research not only focuses on climate monitoring but also includes areas such as ocean protection, sustainable fisheries, and pollution reduction. The oceans are a critical source of food, energy, and culture for humanity, and therefore, stronger protective measures must be implemented to ensure the sustainable use of these resources, safeguarding the quality of life for future generations. Moreover, he highlighted that collaboration among scientists and technical experts from diverse backgrounds can bring varied perspectives, enabling more effective solutions to climate and environmental challenges.

貳、海報展示（Poster Presentation）

海報展示是這次參與科工研討會最重要的環節，如何自信地將自身研究成果以外語的方式呈現給其他各國代表便成了我們一大課題，活動當下所有與會人員皆會集合在一個長廊，可以欣賞各國代表針對這次主題所做出的研究內容，不但可以學習極端氣候相關的專業知識，更可以從中觀察他人表達能力的獨特魅力，進而精進自己；我們也在海報展示的活動結束後進行了閉幕活動，美國海軍官校校長講了一句我覺得印象很深刻的話：「在座的每一位都具備為我們所居住的環境帶來碩大



改變的能力，期許大家持續精實自我，為地球上的人類文明帶來福祉。」能夠參與這樣各國齊聚的研討會，說來也是畢生榮幸，原來我們也可以發揮自身無可限量的潛力，在未來為社會貢獻自己的一份力，最後，我們與各國代表在大廳外的廣場欣賞著美國海軍官校的美景並共進午餐為這次的研討會劃下美麗的句點。

The poster presentation was the most important part of this year's participation in the science and technology symposium. One of the major challenges we faced was how to confidently present our research findings in a foreign language to representatives from other countries. During the event, all attendees gathered in a corridor where we could view the research work of various countries on the event's theme. Not only did we have the opportunity to learn professional knowledge related to extreme climate, but we could also observe the unique charm of others' presentation skills, which inspired us to improve ourselves. After the poster presentation, we attended a closing ceremony where the President of the U.S. Naval Academy made a statement that left a deep impression on me: "Each of you has the ability to make a significant change to the environment we live in. I hope you will continue to refine yourselves and bring well-being to human civilization on Earth." Being able to participate in such an international symposium is truly an honor. It made me realize that we too can tap into our limitless potential and contribute to society in the future. Finally we shared a wonderful moment with representatives from various countries, enjoying the beautiful scenery of the U.S. Naval Academy and having lunch in the plaza outside the hall, marking a beautiful conclusion to the symposium.