出國報告（出國類別：國際會議）

出席 **2016** 年亞太氣候研討會報告 **(APEC Climate Symposium, APCS)**

服務機關：交通部中央氣象局

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派赴國家：秘魯

出國期間：**105** 年 **9** 月 **14** 日至 **9** 月 **21** 日

報告日期：**105** 年 **12** 月 **8** 日

摘要

亞太經合會(Asia Pacific Economic Cooperation；APEC)氣候中心(APEC Climate Center, APCC)每年例行舉辦亞太氣候研討會(APEC Climate Symposium, APCS)。有來自全球 21 個 APEC 會員經濟實體、超過 80 名人員參與，與會人員包含各經濟體的科學家、水文或氣象部門的代表、官員、學者、媒體等相關人士。2016 年 APCS 在 9 月 16 日至 18 日，於秘魯的皮魯拉市(Piura)舉辦，其主題為「智慧型的氣候資訊與負責任的行動：在多變的世界實現永續的糧食安全」，此次研討會透過支持區域合作，提出氣候變遷對農、漁業，以及區域的糧食安全的影響，做為科學和政策間溝通的橋樑。此外，研討會中亦探討極端氣候事件在短期內對農業的影響，探索氣候資訊如何運用於找出糧食問題的長期解決之道，以及氣候科學在漁業所扮演的角色。

在研討會中，專家提到未來糧食需求會因人口上昇而增加，但目前農耕地、海洋捕撈魚獲量雙雙接近飽和，可再增加的空間有限。惟水產養殖仍有成長的空間，是未來提供更多糧食的重要選項之一。在氣候變遷影響下的未來，糧食價格預期將上昇、價格波動變大，但糧食品質下降。此外，熱帶地區及沿岸魚群未來可能有減少趨勢。專家們多次呼籲，維持生態健康、優質環境極為重要，農漁業要能確保永續經營，必須在獲取糧食及保持生物多樣性之間取得平衡。這些關於糧食安全的預測及建議，政府單位應重視且提早因應。

關鍵詞：氣候變遷、氣候預報、氣候資訊應用、糧食安全

目次

一、目的

亞太經合會(Asia Pacific Economic Cooperation；APEC)為目前臺灣能參與的國際組織之一，其會員環繞太平洋地區，分別有臺灣、日本、韓國、中國大陸、菲律賓、美國、加拿大、俄羅斯、澳大利亞、智利、印尼、秘魯、泰國、越南等 21 經濟實體(圖 1)，是亞太地區中一個重要的世界經濟組織。APEC 在 1998 年時便有成立氣候中心的規劃，經數年努力，最終 APEC Climate Center (APCC, http://www.apcc21.net/main.do?lang=en) 在 2005 年於韓國釜山成立。APCC 蒐集包含我國中央氣象局等，各個先進國家(圖 2)的天氣及短期氣候預報資料，經整合及分析，提供 APEC 會員乃至於全世界各地的短期氣候預報資料，協助各國對可能來到的氣象災害提早因應。

APEC 自 2004 年起，每年均有舉辦亞太氣候研討會(APEC Climate Symposium, APCS)，此研討會為 APCC 年度盛事。本次 2016 年 APCS 在 9 月 16 日至 18 日，APEC 與秘魯的國家氣象與水文服務局(National Meteorology and Hydrology Service of Peru, SENAMHI)共同於秘魯的皮魯拉市(Piura)舉辦，主題為「智慧型的氣候資訊與負責任的行動：在多變的世界實現永續的糧食安全」有來自世界各地超過 80 名與會人員，成員包含各經濟體的科學家、水文或氣象部門的代表、官員、學者、媒體等相關人士。2016 APCS 透過支持區域合作，提出氣候變遷對農、漁業，以及區域的糧食安全的影響，做為科學和政策間溝通的橋樑。此外，研討會中亦探討極端氣候事件在短期內對農業的影響，探索氣候資訊如何運用於找出糧食問題的長期解決之道，以及氣候科學在漁業所扮演的角色。

氣候變遷已經發生，未來也不可避免，甚至情況會將更加嚴峻。面對如此的挑戰，糧食安全議題如何因應，會在研討會中被充分討論。這是個了解氣候變遷與糧食安全的絕佳機會，身為地球村一份子的臺灣不應缺席，要積極參與，並在研討會中學習新知。

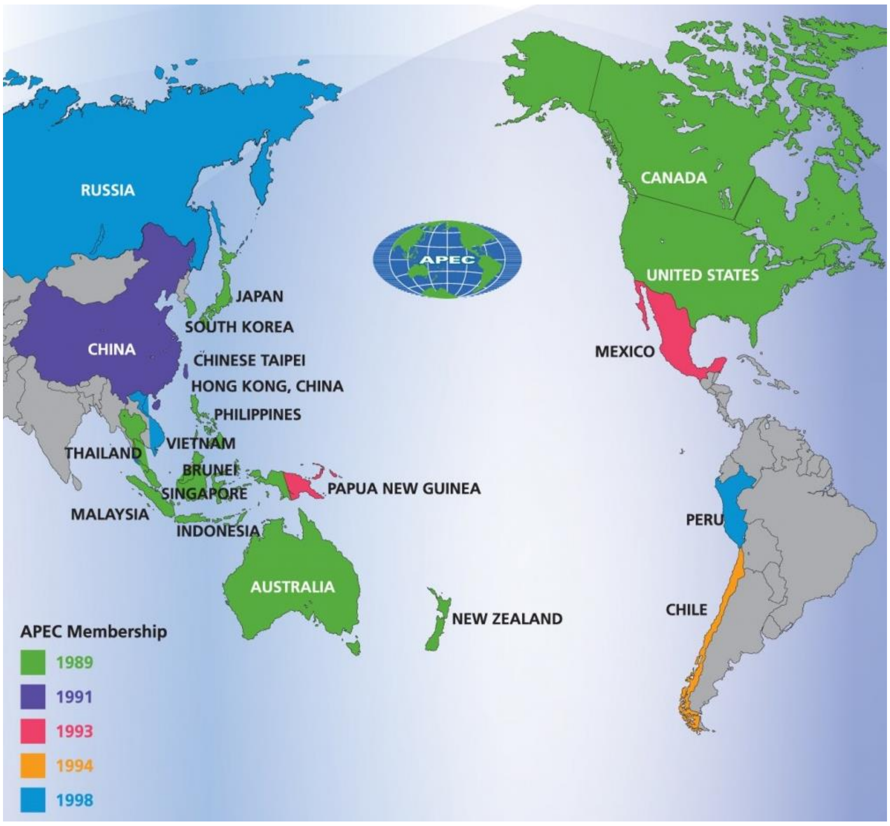

圖 1：APEC 會員及入會年份，圖檔來源：http://www.transpacificproject.com/

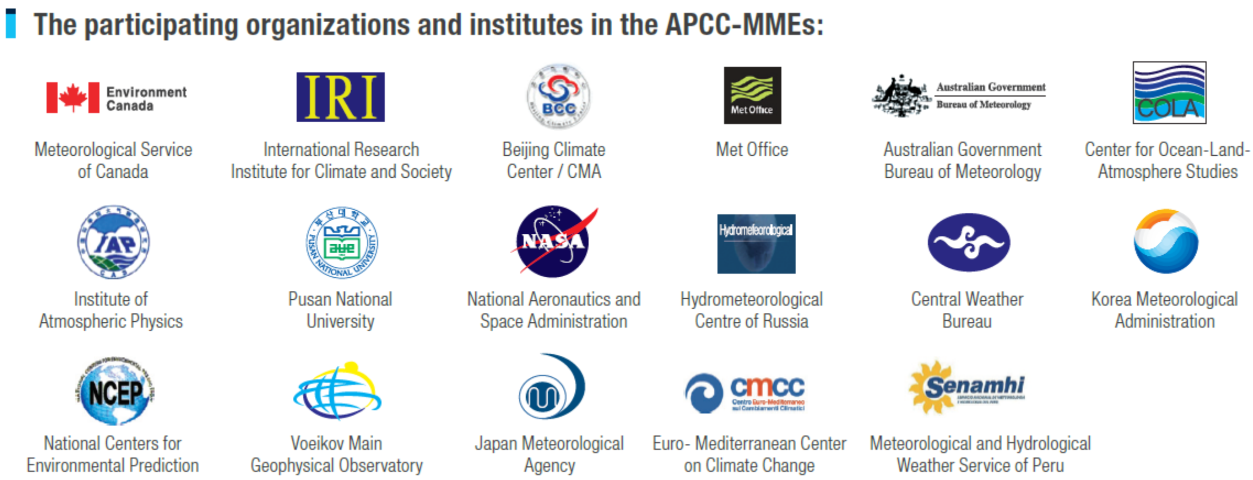

圖 2：參與 APCC 多國系集模式的成員組織，本國中央氣象局(第 2 排右 2)亦是其中一員，圖檔來源為 APCC。

二、過程

此次與會行程說明如下：

日期	地點與相關工作內容
2016/9/14~9/15	出發前往，臺北→美國洛杉磯→秘魯利馬→秘魯皮魯拉。
2016/9/16~9/18	參加 2016 年亞太氣候研討會(APEC Climate Symposium, APCS) 1. 9 月 16 日, 8:00~12:00：註冊、開幕、關鍵議題講座。 2. 9 月 16 日, 13:00~18:00：主題一，農業上的氣候科學應用：極端天氣與氣候事件對農業的影響。 3. 9 月 16 日, 18:30~20:00：迎賓晚宴。 4. 9 月 17 日, 9:00~14:50：主題二，應用氣候科學規劃農業長期計劃。 5. 9 月 17 日, 15:00~19:20：主題三，氣候變遷對漁業威脅之長期因應方案。 6. 9 月 18 日, 9:00~12:00：主題四，綜合討論。 7. 9 月 18 日下午：卡塔考斯(Catacaos)觀光行程。 詳細議程請參閱附件 3。
2016/9/19~9/21	返國，秘魯皮魯拉→秘魯利馬→美國洛杉磯→臺北。

三、心得

本次研討會的議程如附件 3，此次研討會首先由 APCC 國際事務組(External Affairs Department)的 Sangwon Moon 女士主持。在她的介紹之下，APCC 主席 Hong-Sang Jung 博士、秘魯國家氣象與水文服務局(National Meteorology and Hydrology Service of Peru, SENAMHI) Eng. Amelia Ysabel Díaz Pablo 局長、南韓駐秘魯代表 Keun Ho Jang 女士以及秘魯環境部副部長 Marcos Gabriel Alegre Chang 女士先後上臺致詞。在各與會者的大合照後，開始了第 1 日上午的關鍵議題講座，緊接者是三大主題的邀請演講與討論。主題分別為：

1. 農業上的氣候科學應用：極端天氣與氣候事件對農業的影響(Utilizing Climate Science in Agriculture: Impacts of Extreme Weather and Climate Events on Agriculture)，
2. 應用氣候科學規劃農業長期計劃(Employing Climate Science for Long-Term Agricultural Planning)以及
3. 氣候變遷對漁業威脅之長期因應方案(Long-term Solutions for Threatened Fisheries Caused by Climate Change)。

議程最後一天第 3 日的上午請到 Mark Howden 博士等人，共同帶領與會人員回顧及總結前兩日的議程(Session IV: Wrap-up & Panel Discussion)。各演講者的報告內容，將於下一小節簡要描述。另外，秘魯當局當日(9/18)下午安排簡短的觀光行程，帶領各與會者前往會場鄰近卡塔考斯(Catacaos)小鎮參觀。

(一)關鍵議題講座

研討會的第 1 位演講者，Ana María Loboguerrero Rodriguez 博士講題為「降低氣候變遷對食安的風險衝擊(Reducing risks to food security from climate change)」。她強調在

人口成長及氣候變遷的雙重衝擊下，每十年的糧食需求量約增加 14%，同時卻有超過 15 億人居住在糧食缺乏的地區。另外，約有 41%的成年人深陷於營養不足的困境；但亦有 46%的成年人有過重或肥胖的問題。Rodriguez 引述其他人的研究指出，若趨勢不變，為了生產更多的糧食，在 2050 年之前約有 1000 萬平方公里的森林會被砍伐，這將會造成更多的二氧化碳排放至大氣中。她亦討論到現行的氣候與農業科學，氣候與農作物模式(climate and crop model)的缺點，就是對評估未來情境仍有許多的不確定性(圖 3)。Rodriguez 亦有注意到現行科學界對氣候變遷與糧食安全兩者之間的相關研究太少，如 Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report 對此一議題的篇幅就太短。她認為科學界比較注重理論的研究，關於實際應用於食安上的研究就相對缺乏。Rodriguez 亦解釋到氣候變遷對食安的衝擊，目前全球稻米、玉米、小麥的可耕地面積有減少趨勢，所生產的糧食品質亦逐漸降低。除此之外，糧食的價格卻逐步昇高，這將對貧窮地區造成更大的衝擊。

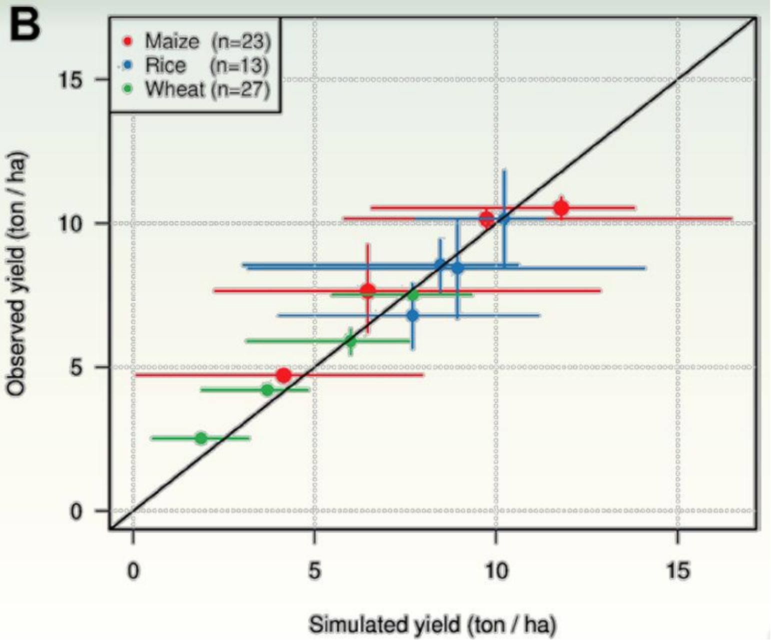

圖 3：農作物系集模式(multi-crop model，橫軸)與實際觀測(縱軸)對玉米(紅，23 個模擬)、稻米(藍，13 個模擬)、小麥(綠，17 個模擬)的散佈圖，每一圓點代表觀測的平均及模式模擬的中位數，垂直及水平的誤差線(error bar)分別代表觀測及模擬的最大及最小值。由圖可發現，模擬的分散度遠大於觀測，代表模式的能力仍有待加強。圖摘自 Ana María Loboguerrero Rodriguez 的簡報。

第 2 位關鍵講座邀請到 Laura Meza 女士，她引述聯合國食物與農業組織(Food and Agriculture Organization of the United Nations, FAO)對食安的定義：「食安議題無時無刻存在於每個人身上，不管個人社會經濟的條件如何，均需能確保能攝取到足夠、安全且營養又能符合個人偏好的飲食，以使每個人有個積極且健康的生活(Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.)」。Meza 女士亦提到，估計 2050 年全球人口將達到 90 億，屆時糧食需求比現在增加 60%；而且，據世界銀行(World Bank)推估 2030 年時，因氣候變遷而增加的貧窮人口將再增加 1 億，糧食分配不均也是問題所在，估計 2010 年全球因過重或肥胖問題消耗 1.4 兆美元，但同時營養不足的貧窮人們亦有 2.1 兆美元的花費。Meza 女士提到家畜會排放大量溫室氣體，其中以牛隻的排放量最大，更會釋出暖化效應更高的甲烷(圖 4)。Meza 表示，為了因應氣候變遷帶來的衝擊，食安可朝以下幾個方面調整。首先，改善氣候研究與營養健康相關之間的連結，使兩個不同領域的學門相互間有更多的認識。其次，逐步增加氣候-糧食-水資源之間的整體性的系統分析。再者，尋求氣候變遷與食安之間兩者的共通利益。最後，食安發展的未來規劃，必須考慮氣候變遷的影響。

Meza 隨後討論到氣候變遷除會造成糧食平均產量下降外，亦會使得出口量降低、進口量上昇，這將加大糧食價格的波動。因此，我們必須制定國際協定或其他積極有效的方法來緩和氣候變遷帶來的負面影響。具體的政策建議方面，Meza 認為科學研究必須以農、漁民及其他相關從業人員的角度出發，開發更有適應性的農漁品種，發展能增加產量的新科技。她還呼籲科學界與政策製者要能加強彼此間的雙方對談，科學界要能提供氣候變遷影響的證據，幫助政策決策制定符合氣候變遷情境下的貿易政策。

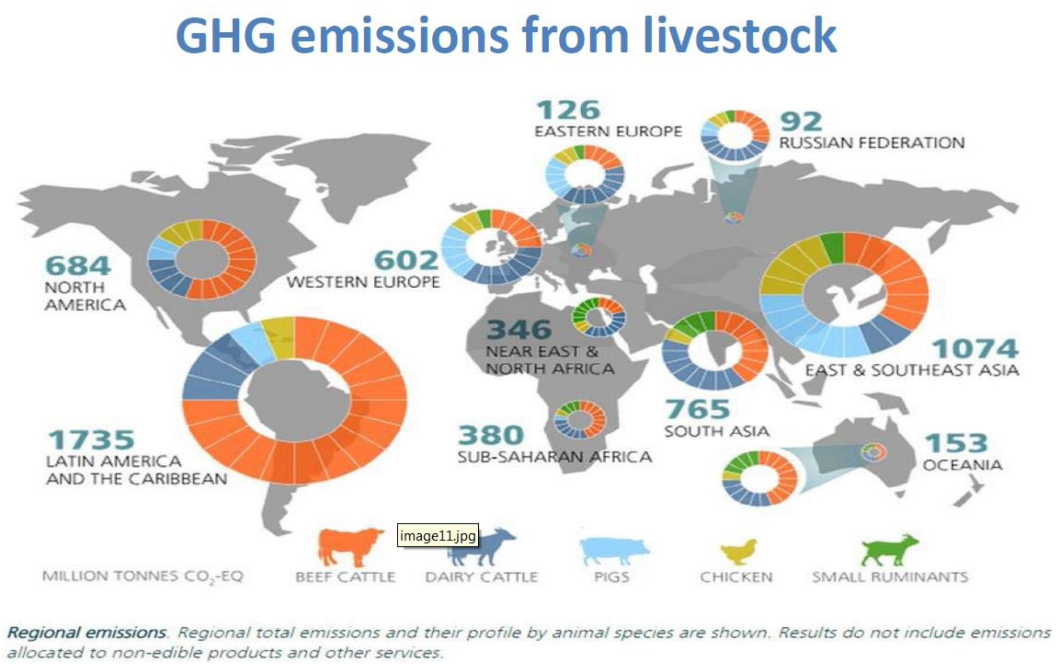

圖 4：全球因畜牧業產生的溫室氣溫排放量，由圖可發現牛隻的排放量最大。摘自 Laura Meza 簡報。

(二)主題一，農業上的氣候科學應用：極端天氣與氣候事件對農業的影響

來自 Lowa state University 的 Elwynn Taylor 教授有著濃濃的學者氣息，他先以秘魯為聖嬰現象發源地的引言開始，討論到氣候總是在變遷，但問題是，我們必須了解變遷是多大、多快及來自何方。接者，Taylor 教授提到氣候、人口、農業三者之間存在惡性循環，舉例來說，人口上昇會增加耕地面積、減少森林覆蓋率，使溫室氣體含量上昇，進而改變氣候，變遷的氣候亦會反饋影響人口及農業。以美國和菲律賓為例說明，Taylor 教授認為暖化造成的夜間溫度上昇，是穀物產量減少的關鍵因素之一；此外，因白天增溫幅度小於夜間，暖化亦會使日夜溫差縮小，可能也會影響作物的生長。他也建議，未來必須加強科學家、農業推廣人員及農民之間的聯繫，共同了解及管理氣候變遷帶來的可能風險。

Ken Takahashi 博士是秘魯當地的氣象學家，他回顧文獻指出，聖嬰現象依海溫形態可分為東太平洋、中太平洋兩類，秘魯對此兩類聖嬰有近似相反的氣候反應。他更進一步說明，南美沿岸的海溫對秘魯氣候的影響比上述兩類聖嬰更加明顯。然而，目前的

氣候模式對南美沿岸海溫及降水的預報能力不佳(圖 5)，增加秘魯氣候預報的難度。

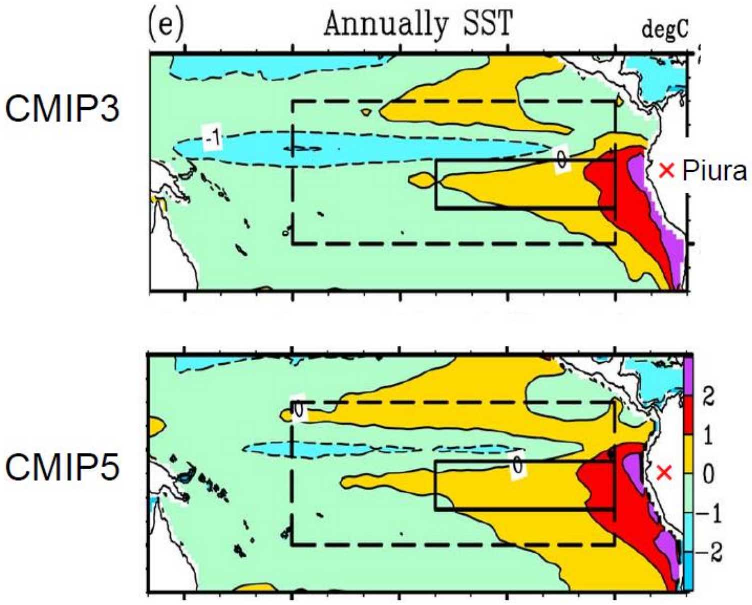

圖 5：CMIP3、CMIP5 [註1] *兩組氣候模式在海溫上的誤差，由圖可發現秘魯沿岸的誤差最大，摘自 Ken Takahashi 簡報。*

Govindarajalu Srinivasan 博士認為科學界與農業實作人員間溝通上存在很大的歧見，因此，負責在兩者之間溝通的連結單位就很重要。此一單位需要有能力將新的科學發現、新發展的技術帶進實際運作中，並且有足夠的政策影響力。

Julian Ramirez-Villegas 博士來自哥倫比亞，他指出氣候約可影響 1/3 農業產量的變異量。只要透過適當的管理，就可盡量減少因氣候變異造成的作物損失。關於氣候智慧管理(climate-smart management)，Ramirez-Villegas 認為可以通過大數據(Big Data)的分析，提供自下而上的方法，改善水稻作物的管理並提高產量，可以說是農業的下一個重大革命。Ramirez-Villegas 隨後分享了一個關於使用統計預測模式的成功案例，農民根據他們的預測來調整稻米的播種日期，因此降低乾旱帶來的損失。

美國 NASA 科學家 Alexander Ruane 博士認為風險具有複雜性，氣候和社會經濟皆

[1] *CMIP 為偶合氣候模式比較計劃(Coupled Model Intercomparison Project)的簡寫，CMIP3, CMIP5 代表 phaee 3, 5 of the CMIP，分別是政府間氣候變化專門委員會(Intergovernmental Panel on Climate Change, IPCC)最近兩期報告(AR4, AR5)所依據的模式資料。CMIP3, 5 包含現今數個先進模式中心所發展的氣候模式。*

可影響風險的大小。Ruane 博士提到完整的地面、遙測觀測系統，加上農作模式，構成農業監測和評估的三大支柱。然後他分享了農業模型比較及改進計畫（Agricultural Model Intercomparison and Improvement Project, AgMIP），此一計畫正嘗試改進模式能力、加強對風險影響因子的了解，亦以改善氣候、作物、畜牧業，經濟，糧食安全和營養彼此間的連結為目標，期望農業部門能對抗氣候變遷的三重衝擊，即適應、減緩、均衡生產。

韓國 APCC 的 Kwanghyung Kim 博士分享了幾個成功的案例，說明建設和強化農業氣象服務時會遭遇的困難。Kim 進一步指出，決策者需要有管理不同氣候風險的能力，並對民眾提供客制化的資訊，使民眾能因應不同氣候變化。但是，要建立所謂的氣候智慧型農業(Climate-Smart Agriculture, CSA)之前，必須先建設完善的觀測系統，呼應 Julian Ramirez-Villegas 博士提到的大數據分析的重要性。

Roberto Quiroz 博士以馬鈴薯為例，說明氣候變遷對農作物的影響。他指出極端天氣、氣候事件已變得更加頻繁，影響程度也更大，為因應未來的挑戰，我們需要發展與製定因應方案。以居住安地斯山的馬鈴薯農民為例，他們利用不同品種的組合、交錯的種植方式，將馬鈴薯種植在不同海拔高度，並採用一系列管理和育種策略。另外，Quiroz 發現，因全球暖化造成的溫度上昇，馬鈴薯種植的海拔高度有愈來愈高的趨勢。

在主題一所有演講者都完成口頭報告後，緊接的是綜合討論議程(Wrap-up and Discussion)。多位專家重申資料的重要性，唯有完整的氣象觀測與農業記錄，才能有助於科學家建立更完善的氣候-農業模型。然而，完整的觀測系統目前僅能在高開發實現，低開發且承受氣候變遷能力較弱的國家缺少密集的觀測系統(圖 6)，這將使得弱勢國家更加弱勢。亦有專家提醒，氣候資訊對其他領域常是艱深難懂的，政策決策者也往往不採納氣候專家的建議。因此，我們要努力將氣候資訊確實且有效地傳遞至各個層面。氣象資訊的傳播，需因地制宜，例如，其中有一位專家分享了塞內加爾的經驗，他們利用農民最常接觸的廣播系統，讓農民能接到並了解有用的氣象資訊。

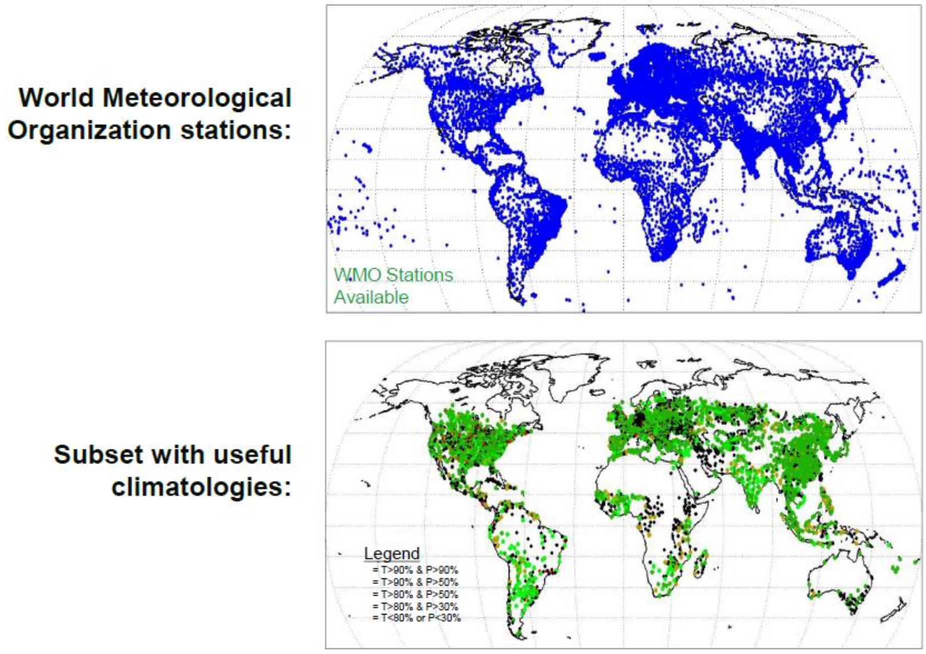

圖 6：全球觀測站分佈圖，摘自 Alexander Ruane 簡報。

(三)主題二，應用氣候科學規劃農業長期計劃

Toshichika Iizumi 博士來自日本,他討論到現今農牧業用地已經佔地球無冰地的 1/3 以上的面積，更使用了近 70%的淡水資源，排放約 13.5%的人為溫室氣體總量。預測 2050 年前糧食需求量將增加 60~110%，超過目前可預期能增加的產量，即未來可能發生糧食需求高於產量的困境，糧食安全正面臨氣候變遷帶來的嚴峻挑戰。Iizumi 博士應用全球網格作物模型(global gridded crop model, GGCM, 圖 7)發現，若全球均溫比工業化前高出攝氏 1.7 度，低收入經濟體將無法承受，糧食產量將會停滯；但高開發度國家可承受升溫達攝氏 4.7 度的衝擊，說明弱勢國家未來的處境可能更加嚴峻。最後，他提到過去幾十年中某些地區的農業發展(或適應)不足以抵消掉氣候變遷的負面影響。他還強調，為了對未來氣候變遷能有更好的調適，長期性的全球農產監測系統、對氣候變遷的更多了解、相關政策的管理等方面，都是必需努力的方向。

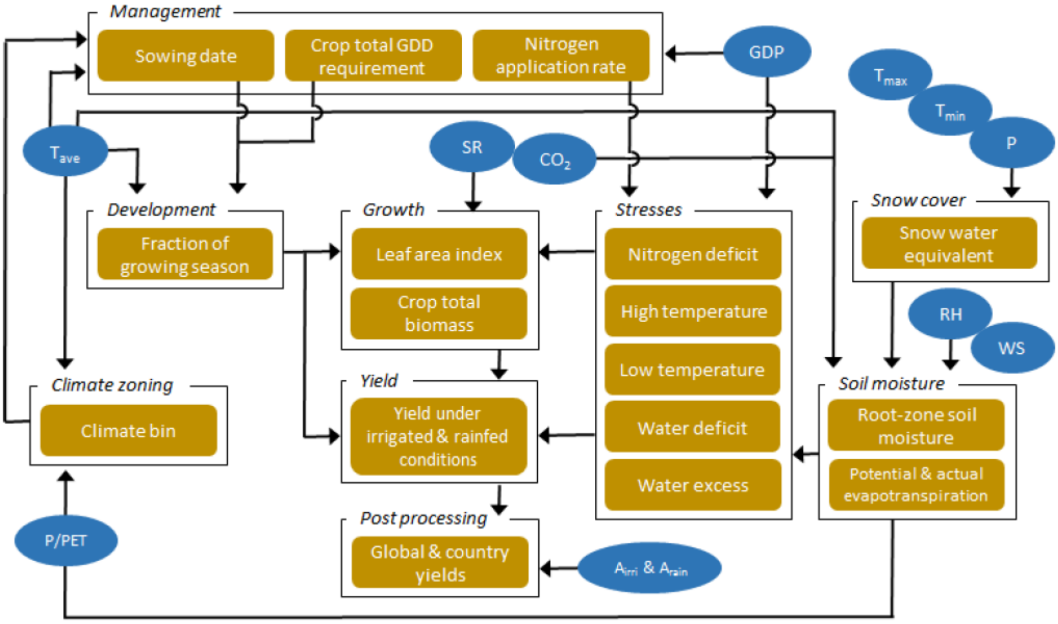

圖 7： 全球網格作物模型(global gridded crop model, GGCM)架構，摘自 Toshichika Iizumi 簡報

Mark Howden 博士用一系統有趣的卡通圖片，說明多數人對氣象的不了解，導致在闡釋氣象時有錯誤的理解(圖 8)。Howden 亦談到季節氣候預報的困難。他認為在充滿不確性的機率性預報中，如何將資訊有效地傳達給決策者，讓他們了解季節預報真正想表達的資訊及使用極限，是氣象單位進行季節預報很大的挑戰。亦即，與不同領域的溝通，是氣象從業人員需要持續改進的課題。

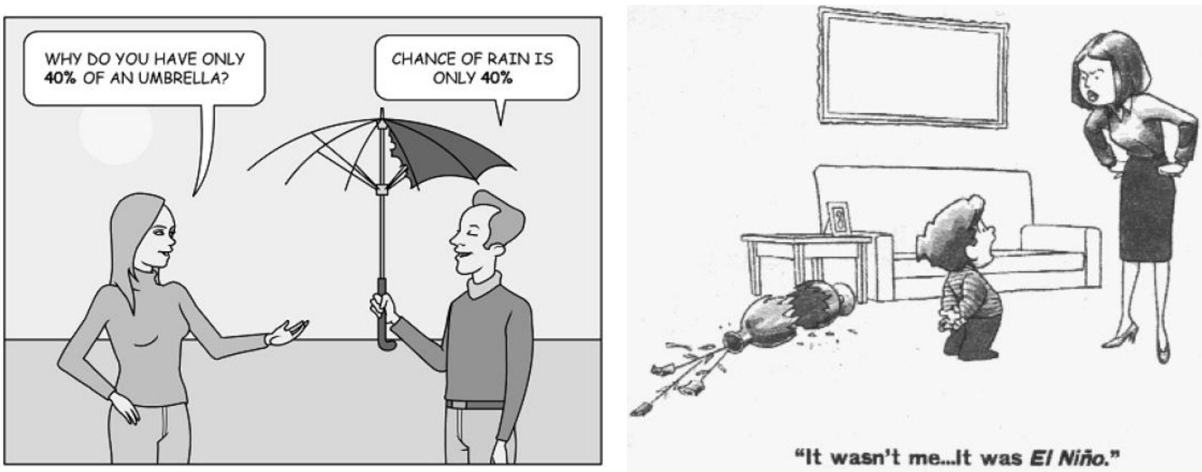

圖 8：說明多數人對氣象資訊錯誤闡釋的卡通，摘自 Mark Howden 簡報。

Ho-Young Kwon 博士提到未來人口會持續增加，且增加率以中低收入國家較高，在發展中國家未來的糧食價格將會更高。若不對氣候變遷的衝擊進行任何調整，未來可能會發生糧食產量下降、價格大幅上昇等問題(圖 9)。因此，他引入氣候智能型農業(climate-smart agriculture, CSA)的概念。CSA 的目標除持續提高農業的產量外，亦期望農牧業能更有彈性以因應氣候變遷的衝擊。Kwon 博士的模擬研究發現，CSA 可減緩氣候變遷帶來的衝擊，使糧食價格在未來不至於增加太多，但 CSA 對於減緩溫室氣體排放的成效不明顯。

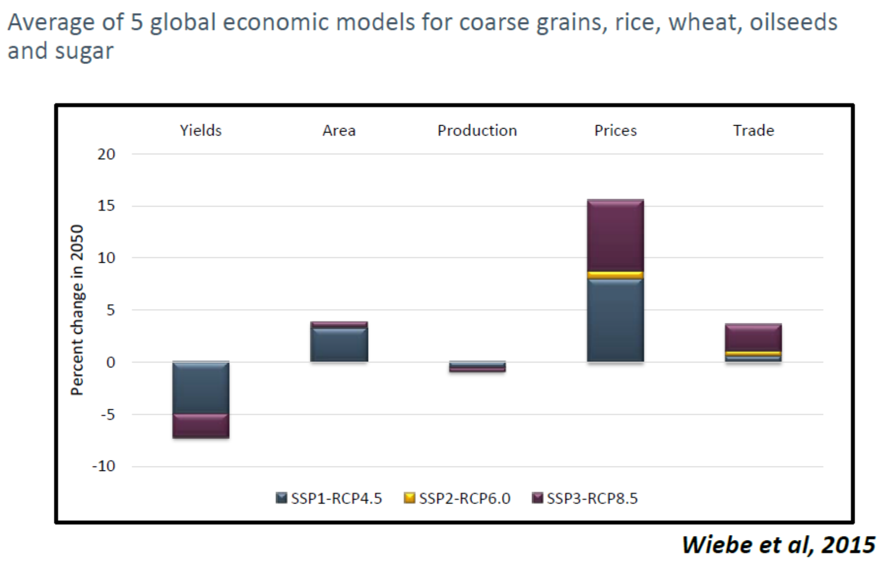

圖 9：在不同情境模擬下，2050 年在糧食產量、農耕面積、產品、價格、貿易量的變化量估計，摘自 Ho-Young Kwon 簡報。

如同許多專家提過的，Maximo Torero 博士也再次重申氣候變遷會使得糧食價格波動變大。關於貿易與溫室氣體排放，Torero 博士認為它同時有正、負面兩種影響。負面影響方面，因糧食的運輸導致排碳量大增。此外，貿易也可能開發新市場，生產量勢必跟著提升，造成更大的環境影響。正面影響方面，可藉由種植某些碳足跡較少的農產品來進行貿易，取代排碳量大的作物，達到減碳的效果。另一方面，提升運輸的科技也可適度減少碳足跡。Torero 評估了 APEC 會員間氣候變遷對農業的影響指出，2050 年時不同區域的農業價格因地而異，多數地區是價格上揚，惟在北美是下跌；另外，不同經濟能力的國家也有不同的價格漲跌(圖 10)。

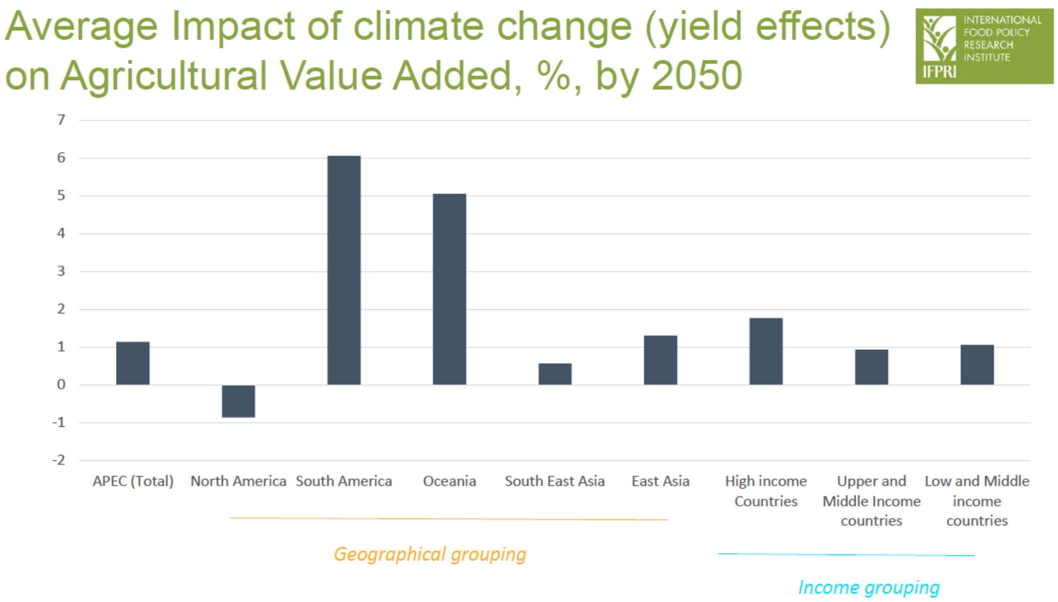

圖 10：不同區域(APEC 全體、北美、南美、澳洲、東亞)、經濟能力(高收入、中高收入、中低收入)在 2050 年時的農業價值變動，摘自 Maximo Torero 簡報。

Willingthon Pavan 博士介紹了一系列可提供氣候相關資訊的儀器，用來幫助巴西農民及政府決策時的參考。例如自動化地面觀測系統、區域氣象模式、衛星遙測系統、空拍機…，他亦介紹利用攝影顯影技術來自動偵測農作物的數量與成熟度。整合模式可以用來偵測、評估病蟲害的分佈，亦可用來協助作物進行風險管理評估。巴西亦發展多平台 APP，除可預測植物病害風險，更可讓民眾便利地接收到相關的整合資訊。

主題二最後兩位演講者都是來自秘魯的專家。David Ellis 博士探討了如何利用農業作物的生物多樣性，來達到永續生產的潛力。以秘魯安地斯的農民為例，為了分擔風險，農民栽種數個不同品種的馬鈴薯。同樣來自秘魯的 Engineer Grinia Avalos Roldán 女士介紹了全球氣候服務框架(Global Framework for Climate Services, GFCS)。GFCS 主要是將幫助將氣候資訊傳遞至各個層面的服務，藉由 GFCS 決策者可接收並了解到足夠的氣候資訊，做為決策時的參考依據。Avalos 女士分享了一些秘魯的案例，她提到芒果在開花期時對溫度很敏感，降水對芒果生長亦有很大的影響。為減緩芒果受氣候變遷的影響，SENAMHI 開發了氣候服務，通過溫度監測及季節預報雙管齊下，適時提供農民有用的資訊。SENAMHI 發現天氣因素及農業管理同樣重要，依據不同的溫度條件調整開花誘導(floral induction)策略，可確保作物有較高的產量。

在主題二的綜合討論議程中，Kwon 博士澄清到，以全球平均來說，雖然 CSA 緩和溫室氣候排放的成效不明顯，但某些區域是有效果的，例如印度施行 CSA 就能減少溫室氣體排放量。亦有專家討論到在現行的農業技術中都需要加入考慮氣候變遷的影響。另外，目前世界農產品的生產過度集中，約有 60~80%的農產品由特定區域生產、出口。為了緩和上述問題，如 the Rapid Response Forum of the Agricultural Market Information System 等新機構紛紛成立。關於氣候科學與其他部們的溝通，專家們均認為要制定客制化的資訊，以使用者的角度，適當地將氣候科學轉換成他們能理解的內容(語言)。然而，專家亦提到多數農民不關心氣候變遷，因為他們認為那是 50 年後遙遠的未來，農民只專注於近期的天氣變化。另一位專家回應，他說即使農民不在意或不相信，但政府不能忽略氣候變遷，政府需有遠見並制定合適的長期調適方略。

(四)主題三，氣候變遷對漁業威脅之長期因應方案

第三個主題將焦點轉移至漁業，首位演講的漁業專家是 Lauren Weatherdon 女士，她表示近期海溫變化會影響魚群分佈，再論述到因全球暖化造成海溫上升，魚群向極區或更深的海域遷息，推估 2051-2060 年時熱帶地區的最大潛在漁獲量將會比現在減少，而北半球中高緯度海域漁獲量將增加(圖 11)。此外，漁產的品質與魚隻的個體尺寸亦會受到氣候變遷影響。全球暖化將會改變海洋生態，由珊瑚為主改變成藻類占優勢的海洋環境，進而影響魚群數量及種類。在許多發展中國家，漁業是首要的經濟來源，漁業的出口產值約是第 2 名咖啡的 3 倍。對人們生長及健康維持而言，Weatherdon 強調魚肉有許多人體所需的稀有微營養素(micronutrients)及蛋白質，魚肉的營養地位不易被其他食物取代。她引述著名文獻指出，漁獲量減少將威脅到人類健康，特別是那些居住在熱帶地區的發展中國家。

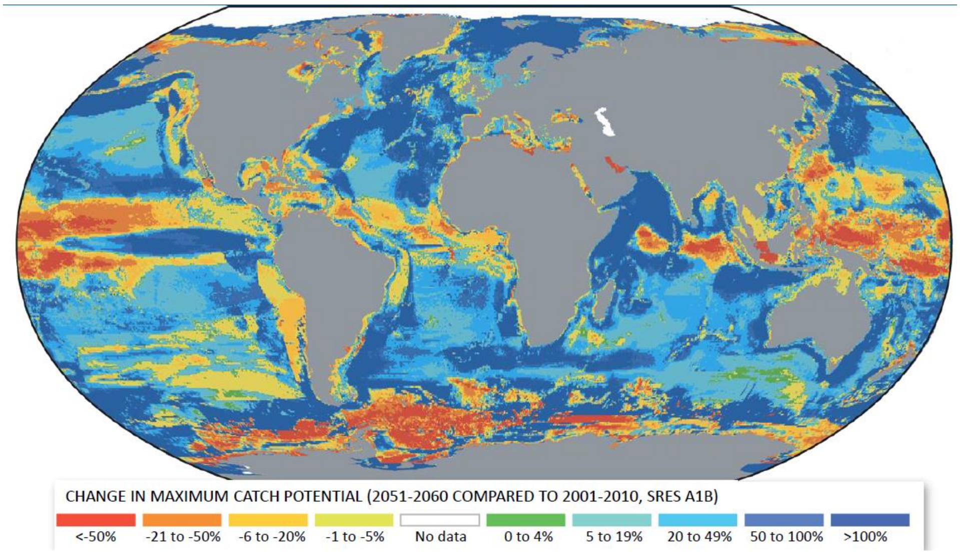

圖 11：最大漁獲潛能的變化推估，時間為 2051-2060 年減去 2001-2010 年，由圖可發現，熱帶海域及沿岸地區的漁獲潛能以減少為主，摘自 Lauren Weatherdon 簡報。

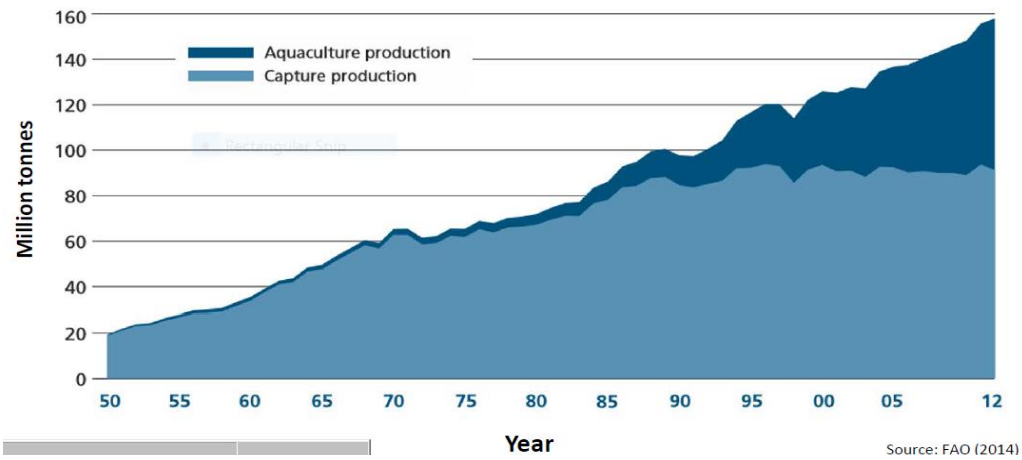

圖 12：1950~2012 年水產產量及漁產捕獲量的時間序列，由圖可發現捕獲量(淺藍色)近 20 多年趨勢持平，摘自 Johann Bell 簡報。

Johann Bell 博士在簡報中提出了兩個問題，首先，氣候變遷如何影響因人口上昇而增加的漁業需求?其次，面對氣候變遷，需要採取哪些適應措施來減少負面衝擊，甚至放大其正面益處? Bell 解釋氣候變遷如何通過影響海洋的物理(海流、海溫)及化學性質，間接影響漁獲量及漁產的股票價格。他以太平洋上的島國為例指出，氣候變遷會造成海洋酸化、海溫升高，這將導致珊瑚礁的侵蝕與珊瑚白化。而且，氣候變遷對珊瑚礁的危害會隨排碳量的昇高而加劇。另外，因海平面上升及風暴強度增加，紅樹林預計到本世

紀末將減少 60%，嚴重危及沿岸魚群的生存環境，造成漁獲量明顯減少。在政策的建議方面，Bell 博士認為唯有良好的管理策略，才有永續經營的漁獲量。他建議要通過政策管理、恢復植被覆蓋、減少對珊瑚礁的捕撈等措施，逐漸回復魚類棲息地的活力。此外，紅樹林是沿岸魚群重要的棲息地，要善加管理，將紅樹林覆蓋區域逐漸向內陸擴張，改善沿海魚類生存環境。最後，增加水產養殖漁業的產量，亦是可行的方向，例如，過去近 20 年捕獲的產量大致持平，但養殖產量卻穩定增加(圖 12)。

Elvira Poloczanska 教授是來自澳大利亞的女士，她討論到面對氣候變遷時，澳大利亞漁業在當今及未來的應變。Poloczanska 教授認為，氣候變遷引發的海氣條件變化，即使幅度不大，也可能透過線性及非線性的連鎖反應，顯著地改變全球海洋的生態環境。Poloczanska 教授在簡報中介紹了氣候變遷速率(the velocity of climate change)，它相當於溫度趨勢除以溫度的空間梯度，即$\mathrm{Velocity} = \frac{temperature\ trend}{spacial\ gradient} = \left[\frac{℃/_{year}}{℃/_{Km}}\right] = [\frac{Km}{year}]$，其空間分佈如圖 13，箭頭方向代表溫度變化最大的方向，正值較高代表海溫水平梯度較小或溫度上昇趨勢較高，負值代表局地冷卻。利用不同魚類對海溫的個別偏好，Poloczanska 團隊發展等溫線軌跡方法，追蹤個別魚類的遷移。她們的結果顯示，熱帶地區物種滅絕的速率超過增加，造成熱帶海域的生物多樣性(biodiversity)減少，對漁業是負面的訊號。而且，熱帶海域生物多樣性降低的困境會隨暖化情境的惡劣而加劇(圖 14、15)。Poloczanska 認為她們發展的診斷工具可來評估氣候變遷帶來的衝擊並做好預防。

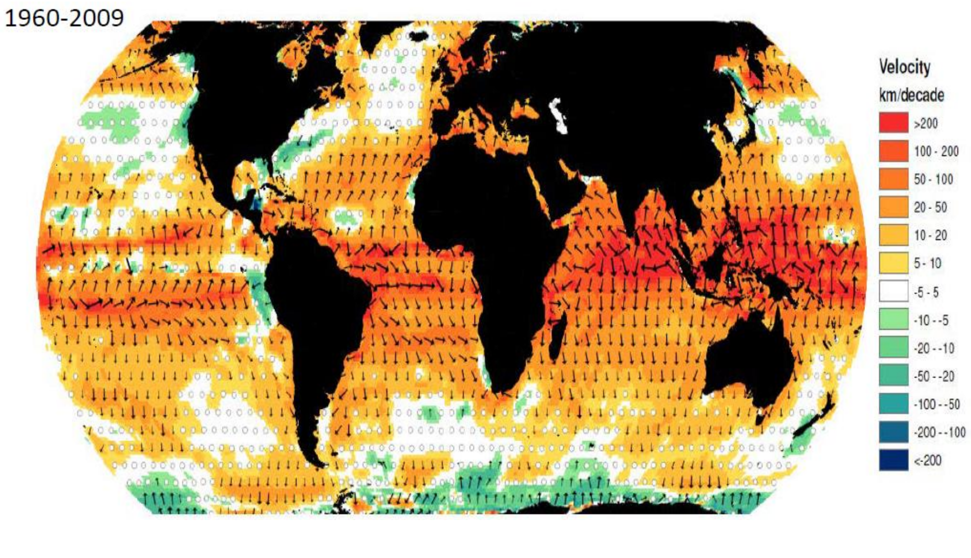

圖 13：1960~2009 年的氣候變遷速率，詳情請參閱內文，摘自 Elvira Poloczanska 簡報。

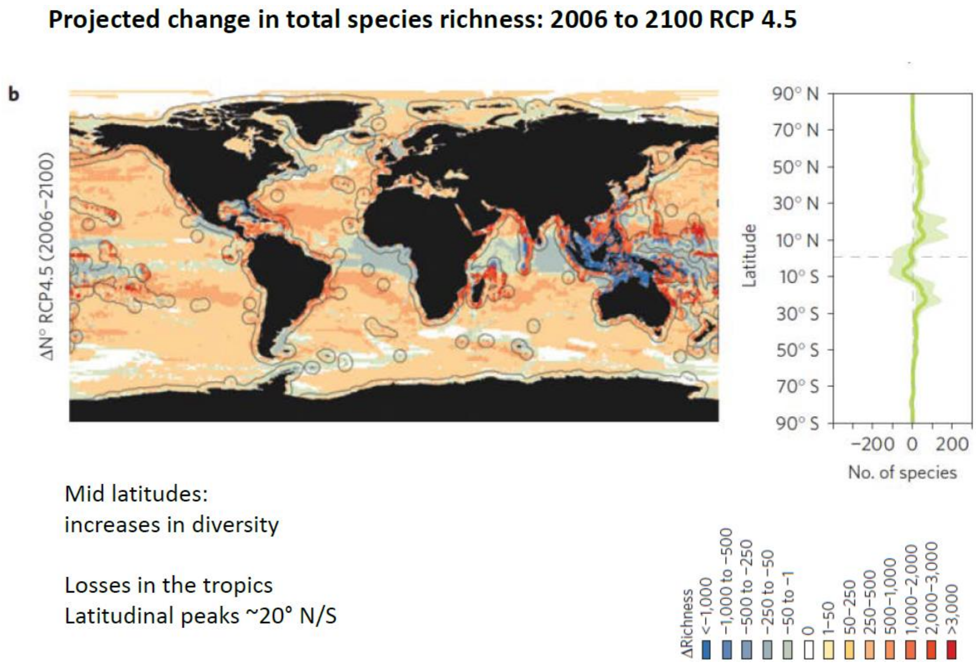

圖 14：在 RCP4.5[2] 情境模擬下，全球魚類種類總額在 2006 年至 2100 年的變化，由圖可發現，在多數熱帶海域的魚類種類總額減少，摘自 Elvira Poloczanska 簡報。

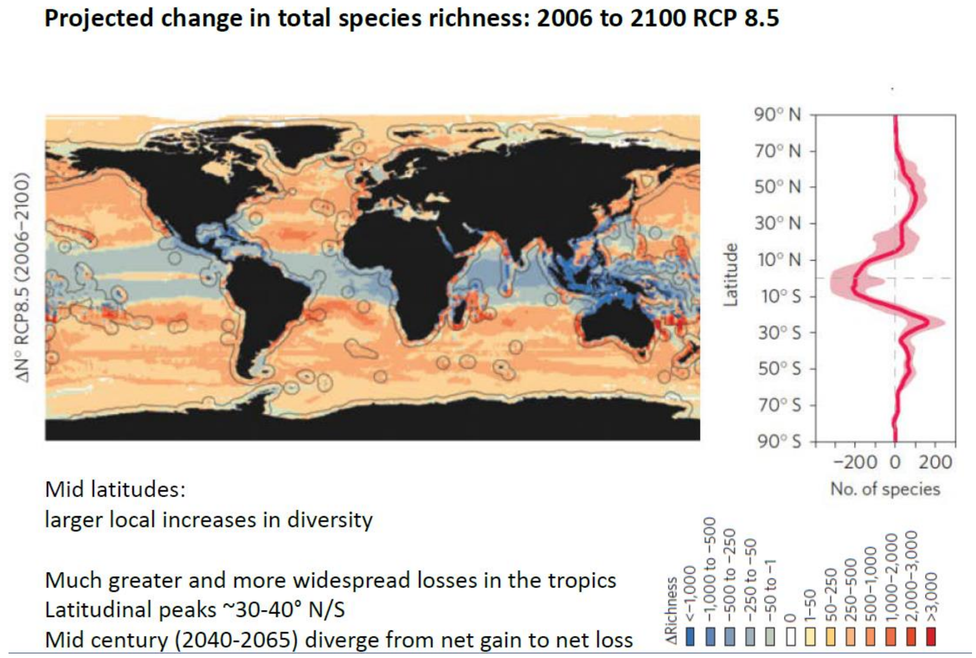

圖 15：同圖 14，惟情境為 RCP8.5，由圖可發現，熱帶海域魚類種類總額減少情況，RCP8.5 比 RCP4.5 更加嚴重，摘自 Elvira Poloczanska 簡報。

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[2] RCP 代表濃度途徑(Representative Concentration Pathways, RCP)是 IPCC 第五次評估報告中，用來定義未來變遷的情境，以輻射強迫作用在 2100 年與 1750 年之間的差異量當作指標性的數值來區分。其中 RCP2.6 代表輻射強迫作用在 2100 年增加了 2.6(Watt/m^2)，同理 RCP4.5、RCP6.0 與 RCP8.5 分別增加了 4.5、6.0 與 8.5(Watt/m^2)，數值愈來代表溫室氣體控制措施愈不積極，暖化情境愈嚴峻。

秘魯當地專家 Dimitri Gutiérrez 博士指出，南美洲沿岸的秘魯涼流(Humboldt current)因海洋湧升流帶來豐富的微生物，提供魚群源源不絕的食物，成為世界上重要的漁場之一，更是全球重要的魚肉、魚油輸出來源。對秘魯及智利來說，有超過 70%的人口，約 5000 萬以上的人民居住在沿岸區，對漁業的依賴頗重。Gutiérrez 博士提到南美西岸的海水酸化程度在比其他海域更為惡化(圖 16)。在全球暖化的未來，因海溫等其他海洋特性的改變，魚隻尺寸也會跟著變化，在熱帶及多數沿岸海域的魚隻尺寸將變小(圖 17)。Gutiérrez 博士回顧過去研究指出，漁業脆弱度以熱帶與極區較嚴重，前者是因為當地的物種滅絕，後者是因為外來種的遷入。再者，在多數 CMIP3 或 CMIP5 的模擬結果中，均顯示極端 El Nino 事件會更加頻繁，降低南美西岸海洋湧升流強度，造成魚群減少。最後，他亦建議漁業要有良好的管理，適當地限制魚群的捕撈量，使漁業能永續經營。

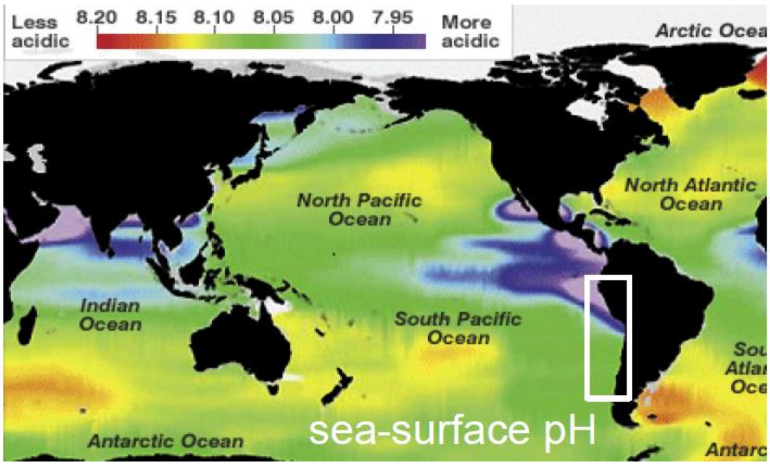

圖 16：近 20 年間全球海水酸化趨勢，摘自 Dimitri Gutiérrez 簡報。

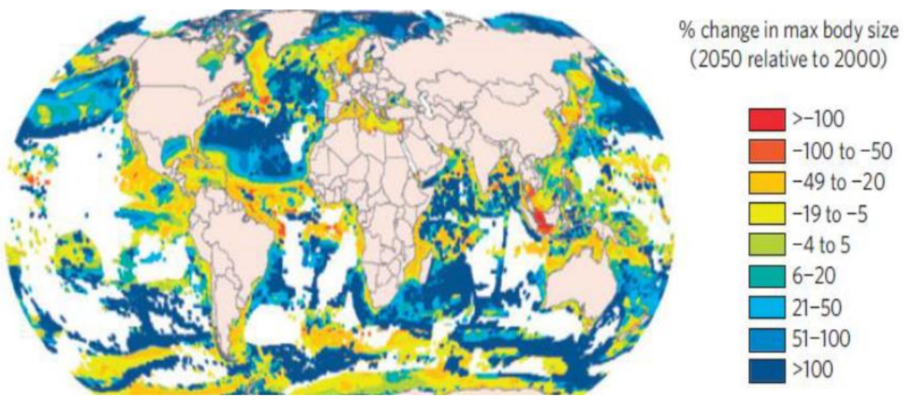

圖 17：魚隻尺寸改變的預測，時間為 2050 年減去 2000 年，摘自 Dimitri Gutiérrez 簡報。

Rashid Sumaila 博士指出全球漁業的經濟價約 1200 億美元，另有約 4000 億美元的附加經濟價值，漁業相關就業人口約有 2.6 億，均說明漁業是全球經濟中重要的一環。如何先前幾位專家的看法，Sumaila 博士亦認為 2050 年代赤道地區的漁獲量及收入將雙雙下降(圖 18)。他也分享其他專家關於氣候變遷如何影響漁業的研究指出，即使只是維持目前的糧食用量及其品質，哥倫比亞未來每年將需額外花費 1.1 億的當地貨幣。Sumaila 也討論到魚類蛋白質在營養方面比其他蛋白質更有價值。然而，他亦批評美國在料理時浪費掉一半的魚肉，如何避免浪費也是對抗氣候變遷中重要的課題。最後，Sumaila 博士呼籲現今的國家及社會對於如何因應氣候變遷多是消極的，多數人只關心當前。他希望，改變從你我開始，所有人都可為關心氣候變遷做出貢獻。

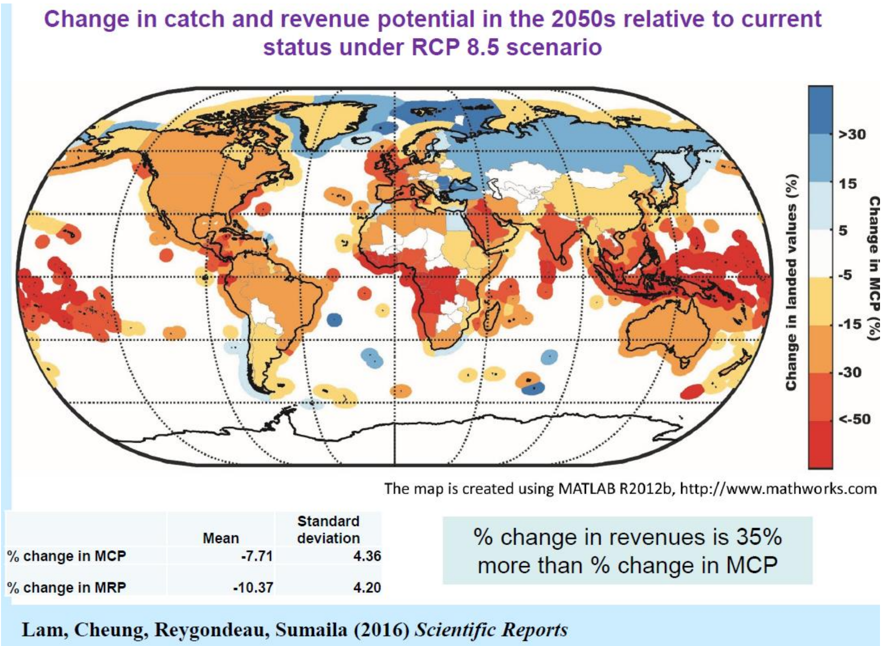

圖 18：RCP8.5 情境模擬漁獲量與收入的變化評估，為 2050 年與現在的差異，摘自 Rashid Sumaila 簡報。

最後一位演講者是 Jake Rice 博士，他亦談到惟有健康的生態系統，才可持續捕獲源源不絕的魚產。Rice 博士認為全球漁業捕撈量在近 20 多年維持穩定，這表明未來漁獲量已接近飽和，產量將不會增加，甚至可能會減少。另一項增加魚類需要的可能方向是水產養殖，但水產養殖是否滿足 2050 年額外增加的 7500 萬噸需求?這個問題的答案仍不清楚。他進一步指出，雖然水產養殖是增長最快的糧食供給系統，並仍有增長的空間；但水產養殖會影響到沿海生態系統的多樣性，亦有其負面影響。此外，水產養殖亦

會壓縮到其他產業的土地及其他資源應用，這些都是推估水產養殖的未來規劃時需考慮的因素。最後，他討論到魚肉及其相關產品是地球上貿易量最高的食品，但是多數的魚類輸出國是相對貧窮、缺糧的國家，而購買魚肉則是相對富裕的國家。因此，Rice 博士質疑漁業的主要目的是為了賺錢，而非供應當地的食用需求。

主題三的綜合討論議程中，有專家提出水產養殖需要的許多資源，如水和飼料等，都與農業的需求重復、相互競爭。漁業專家 Jack Rice 博士回應到，池塘或溪流自然生態中的魚群也是可以提供食物來源的之一。而且，部份的養殖魚類可利用農業中不需要剩餘品飼養。再者，水產養殖的蛋白質產能效率比畜牧業高出得多。另有專家指出，水產養殖的發展還是有許多壓力，例如它需要大量的水及土地。有專家重申，我們必須在漁業及保持生物多樣性之間取得平衡，以確保永續經營。秘魯當地的專家提到，秘魯政府目前對漁業資源正進行了大規模的密集監測，但僅限於少數特定魚種，其他如沿海物種的監測難度更高，這將是預測、監測氣候變遷影響評估的難題之一。Jack Rice 博士對此議題亦有回應，他說目前我們已建立了半個世紀的物種分佈資料庫，藉由熱軌跡模式(thermal envelope models)能可靠地預測魚群的遷息，但如何應用至漁業上又是另一個不同的議題。此外，模式也能預測魚隻尺寸隨海溫升高的變化，我們現行的管理方式也該模式的預測結果因應調整。

(五)主題四，總結及綜合討論

在最後一天上午的議題，首先由主持人 Mark Howden 博士及 3 位專家分別總結前兩日的三大主題。接著，由 Mark Howden 博士、APCC 主任 Heekyung Park 博士及其他 4 位專家，共同帶領與會人士進行問題討論。

在此議程中，有專家認為農漁業間的交流更加頻繁，共同負責供給未來逐漸上昇的糧食需求。在作物選擇方面，有人建議我們應該減少投資那些對氣候變遷調適能力較弱品種，投入更多資源在那些較為對抗氣候變遷衝擊的作物。預估未來人口增長較明顯的區域是發展中國家，這些國家不僅氣候變遷的調適能力較弱，其糧食安全的問題亦較大。

為解決這個糧食短缺的問題，專家建議可由擴大並改善水產養殖，及優化魚類棲息地的管理等多方面進行；另外，野生魚類捕撈潛力仍有些許增加的空間，只是我們要謹慎管理補撈的政策。

專家表示，因糧食安全牽聯到許多不同層面，其影響因素眾多，我們需要建立一套能結合氣候、社會和經濟等資訊的預測模型，並利用它提供可靠的有用資訊，用為政府決策的參考。要達成這個目標，監測資料的收集就很重要，惟有完整的氣象、農漁業觀測系統、日誌，才能逐步建立可靠的預測模型。亦有人提到必須重視農漁民的需求，建立或改善農漁業產品的保險制度。

氣候變遷改變了海洋環境，例如海水涵氧量降低，生物遷息造成的物種多樣性的重新分配，海溫增暖會造成海洋湧昇流減弱，導致魚類數量因微生物減少而降低。其他與漁業有關的氣候變遷研究應再投入更多的心力。

主題三總結的引言人 Johann Bell 博士對未來的調適給了一些方向，他認為水產養殖魚種以草食性或雜食性為優先，這樣就可以使用農產品的剩餘品養殖。擴大小型的水塘養殖場地，並與鄰近的農業整合。他再三強調一再被提出的觀念，海洋的生態環境維護極為重要，海洋漁業的捕撈必須同時考慮維持糧食安全、保護生物多樣性兩個面向。

在最後一個議程，綜合討論(Panel Discussion)中，SENAMHI 的專家分享經驗表示，他們提供了許多資訊，亦持續確認使用者能否實際應用；SENAMHI 希望能改善與政策決策者之間的溝通，也持續進行季節預報能力的改善，氣候變遷與糧安問題相關的研究也投入相當多的資源。

關於如何面對氣候變遷，Maximo Torero 建議，可由如何提高糧食生產效率及減少損失、浪費出發。另外，加強氣象與農漁業的監測網絡也是很重要，而且觀測資料要能公開。氣象等訊息的提供方面，要由使用者角度出發，發佈使用者能理解的內容。他亦同意應投入更多的資源在氣候變遷與糧食安全的研究。最後，政府各部會要能加強溝通對話，讓各單位都能了解氣候變遷與糧食安全的重要性。

四、建議

本次能獲邀出席 2016 年 APCS，在研討會聆聽來自各領域的專家學者，講述氣候變遷與糧食安全的相關議題，著實吸收到不少新知職，收獲豐碩。專家學者提出的許多建議，經整理如下：

1. 目前糧食有分配不均的問題，有過重、肥胖或浪費糧食的問題，亦有許多人處於營養不足的困境。
2. 未來糧食需求會因人口上昇而增加，但目前農耕地、海洋捕撈魚獲量雙雙接近飽和，可再增加的空間有限。
3. 未來人口增加的幅度以開發中國家較大，這些區域承受氣候變遷的衝擊能力較弱。
4. 因人為活動造成的環境破壞及氣候變遷等其他因素，未來糧食價格將上昇且波動變大，糧食品質下降。
5. 因氣候變遷改變海洋生態，熱帶地區的魚群會遷至較高緯度或較深的海域，造成熱帶地區的魚群種類減少，中高緯度魚群種類增加。
6. 沿岸魚群在氣候變遷影響的未來亦可能減少。
7. 氣候變遷亦會影響魚隻的個體尺寸。
8. 水產養殖仍有成長的空間，是未來提供更多糧食的重要選項之一。
9. 水產養殖的魚種可以草食性或雜食性為優先，利用農產品的剩餘品養殖，減少環境壓力。
10. 農漁業要能確保永續經營，我們必須在獲取糧食及保持生物多樣性之間取得平衡。
11. 建立完整的氣象觀測、農漁業的調查報告及紀錄刻不容緩，這些基礎的觀測紀

錄，是建立整合模式最重要的依據。

12. 科學界需能建立一套整合氣象、農漁業等多方面資料的模式，利用模式提供可靠的有用資訊，用為政府決策的參考。

13. 目前非氣象從業人員對氣象資訊常有錯誤的理解，這是氣象作業單位可以努力的方向。

14. 為讓每個領域都能充分了解氣象資訊，氣象提供者需從使用者角度出發，提供客制化服務。

關於重點整理的最後兩點，正是中央氣象局近幾年努力的方向。中央氣象局在過去幾年，陸續辦了公衛、農業、漁業、水資料四個領域的氣象資訊分享研討會。亦已對各農漁會、國小、地方氣象站等對象講解氣候資訊與應用。在中央氣象局官網上，目前也有幾個以口語化的預報產品，如天氣小幫手、天氣週報、主任談天氣等單元。社交網路及微網誌服務方面，也陸續成立了報天氣、報氣候、報天文、Good Weather 古都好天氣-臺灣南區氣象中心粉絲專頁、SOS 地球科學展示系統粉絲團…。也就是說，中央氣象局目前正走在對的方向。未來，應持續且更加著力於此一目標上。

2015 年於法國巴黎的聯合國氣候高峰會(United Nations Climate Change Conference, COP 21)議定書簽署之後，節能減碳的新生活已成為不可迴避的趨勢。與氣候變遷的相關研究，在國際上早已成為熱門的新興議題，各國莫不投入大量的人力與經費於氣候的能力建設。因此，類似 2016APCS 的氣候相關國際研討會，臺灣應更加積極參與。雖然中央氣象局近年已逐漸重視氣候的能力建設，但相對於其他國家還是稍顯不足。舉例來說，國力與臺灣相去不遠的韓國，在 2005 年就投入大量的資源成立 APCC。十多年過去了，韓國的 APCC 已成為可獨當一面，領導區域氣候發展的重要單位。反觀臺灣，我們現有的氣候人才決不遜於韓國；缺乏的，只是一個表演的舞臺。雖然此一舞臺，需投入比現在更多的資源，且非一朝半夕可成的。不過，一旦氣候能力足夠成熟，將可讓臺灣在世界上發光發熱，成為一顆引領區域氣候發展的耀眼巨星。其實，相對於其他領域，氣候研究發展所需的經費真的不算多。若能藉由投入少量資源，獲得防患於未燃的

重大成就，投資氣候研究有著相當大的利益。

本報告記錄研討會重點，惟對糧食安全議題並不熟悉。建議 APCC 辦理氣候變遷與其他領域交流的國際研討會時，除氣象局人員外，其他有關單位亦能派人員參加，期能將研討會的精華帶回，供進一步參考。

此次研討會的簡報及相關資料，APCC 整理在以下網址：

http://www.apcc21.net/ic/apsView.do?lang=en&bbsId=BBSMSTR_000000000031&nttId=4724&pageIndex=1&recordCountPerPage=10&searchCnd=&cate1=&searchWrd=

附件一:邀請函

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Website: www.apcc21.org

18 August 2016

Dr. Ming-Ying Lee
Associate Technical Specialist
Central Weather Bureau
Chinese Taipei

Subject: Invitation to APEC Climate Symposium 2016 and APCC WG Meeting

Dear, Dr. Ming-Ying Lee

Warm greetings from APEC Climate Center!

You are cordially invited to the **APEC Climate Symposium (APCS) 2016** and the annual **APCC WG Meeting**, to be held from **September 16th to 18th in Piura, Peru**.

As the issues of climate variability and change gain prominence in national agendas, APCC strives to provide relevant and actionable climate information to support decision-makers' responses to climate-related hazards. The theme of this year's symposium is 『***Smart Climate Information and Accountable Actions: Achieving Sustainable Food Security in a Changing World.***』 The symposium will help bridge the gap between science and policy through supporting regional cooperation by addressing the impact of climate change on agriculture and fisheries, and thus regional food security. It will explore how the impact of extreme climactic events on agriculture can be addressed in the short term, investigate how climate information can be employed in finding long-term solutions to food insecurity, and discuss the role of climate science for fisheries. I have attached the First Announcement to give you a better idea of the goals and motivations behind the event.

In addition, we would like to attend the annual **APCC Working Group meeting** during the Symposium. The exact date and detailed information regarding WG meeting will be informed in due course.

APCC will cover your travel expenses via economy class with the most direct route, accommodation, and per diem for your participation. We would appreciate a response from you at your soonest. Please contact Ms. Inja Jeon (alliswell1122@apcc21.org) with your response or should you like more information.

Sincerely yours,

HJung

Hong-Sang Jung
Executive Director
APEC Climate Center

附件二:邀請函中譯

李明營博士
技士
中央氣象局
臺灣，中華民國
主旨：邀請您出席2016 APEC 亞太氣候研討會及亞太氣候中心(APCC)工作小組會議

親愛的李明營博士，

我們誠摯地邀請您出席2016 年亞太氣候研討會(APEC Climate Symposium, APCS)以及亞太氣候中心(APCC)工作小組會議，此研討會將在9月16日至18日於秘魯的皮烏拉舉辦。

氣候變異及變遷已成為各國重視的議題，APCC致力於提供重要且可由使用者操作的氣候資訊，使決策者能對氣候災變有所因應。今年研討會的主題是『智慧型的氣候資訊與負責任的行動：在多變的世界實現永續的糧食安全』。此次研討會將透過支持區域合作，提出氣候變遷對農、漁業，以及區域的糧食安全的影響，做為科學和政策間溝通的橋樑。在本次研討會中，將會探討極端氣候事件在短期內對農業的影響，探索氣候資訊如何運用於找出糧食問題的長期解決之道，以及討論氣候科學在漁業所扮演的角色。我已附上第1份公告，它會有助你了解本次研討會的目標和動機。

此外，在本次會期中，我們會舉行亞太氣候中心(APCC)工作小組會議，確切日期及詳細情形將另行通知。

APCC會提供您參與研討會期間的交通費，搭乘最直達航線的經濟艙，及每日生活津貼。我們期待著您儘快的回音。若您有任何疑問，請聯繫Suhee Han 女士(suheehan@apcc21.org)。

Hong-Sang Jung敬上
APCC 主任

附件三：研討會議程及簡要

APEC Climate Symposium 2016

Smart Climate Information and Accountable Action:

Achieving Sustainable Food Security in a Changing World

Piura, Peru
September 16-18, 2016


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Achieving Sustainable Food Security in a Changing World

Contents

Welcome Message

On behalf of the organizers, the APEC Climate Center is delighted to welcome you to Piura, Peru for the APEC Climate Symposium (APCS) 2016. The APEC Climate Center has developed this event to advance climate science to better strengthen food security in the face of large scale environmental change.

Climate change is already affecting food security and the most vulnerable livelihoods in the Asia-Pacific, highlighting its importance for sustainable development and economic growth. With such a diverse group of participants bringing together experiences from both emerging and advanced economies, this event provides a unique opportunity to link advances in science with lessons learned from across the globe to promote regional food security.

We are excited to have such a phenomenal group of experts ready to share their knowledge and such an interested group of participants to enhance discussions. It is our hope that participants will return to their home economies enriched by the information and case studies shared over the next days and can apply their learning towards reducing the vulnerability of their agriculture and fisheries towards both short- and long-term climactic events.

APCS 2016 would not have been possible without the strong support of our valuable partners. I would like to offer our sincere gratitude to all the members of the Organizing Committee and our co-hosts at the Peruvian Ministry of Foreign Affairs and the National Meteorology and Hydrology Service of Peru, as well as to all the speakers and participants.

I hope that you enjoy the symposium.

Thank you.

Dr. Hong-Sang Jung
Executive Director, APEC Climate Center

Organizers

APEC Climate Center (APCC)

The Asia-Pacific Economic Cooperation (APEC) Climate Center is a leading climate information service provider in the Asia-Pacific region. We provide climate forecasts and information services, and, using these results to conduct research and implement development activities. Additionally, we organize capacity building initiatives in the Asia-Pacific region such as trainings and APCS. APCC was established in 2005 with the endorsement and warm welcome of the APEC senior officials and leaders. APCC hosts the annual APEC Climate Symposium, which provides a forum for various scientists, academics, policy-makers and other stakeholders to share the latest science innovations in climate prediction and explore climate information applications.

In addition to organizing events, APCC provides operational services such as monthly seasonal outlooks and climate monitoring and prediction products, as well as conducting climate change R&D and developing supporting online tools and data services. At APCC, we strive to strengthen scientific and technical cooperation across the APEC region in order to help economies and societies deal effectively with the consequences of current and future climate-related hazards through the provision of climate information, research, and technical support.

National Meteorology and Hydrology Service of Peru (SENAMHI)

The National Meteorology and Hydrology Service of Peru (SENAMHI) aims at generating and providing meteorological, hydrological and climate knowledge and information in a reliable, timely and accessible manner for the benefit of the Peruvian society.

With the ongoing intention of disseminating reliable and quality information SENAMHI operates, controls, organizes and maintains the National Network of more than 900 meteorological and hydrological stations according to the technical standards established by the World Meteorological Organization (WMO).

Currently, thanks to the development of a modern public policy for disaster risk management, Peru has been improving its mechanisms of formulation and implementation of actions aimed at preventing risk in priority areas through increased synergies between different public entities that take part in the National System for Disaster Risk Management.

The orientation of management by results and products with a final destination is the framework in which SENAMHI´s new institutional paradigm is developed, linked to the development of products and provision of services based on user's needs.

Overview and Session Information

Since 2005, the APEC Climate Center (APCC) has hosted the APEC Climate Symposium (APCS) in partnership with the APEC Host Economy. Each year, APCC selects a priority topic with important linkages to climate science. Despite recent advances in climate science and related applications, there are often large gaps in its use in the implementation or management of relevant issues, particularly in developing economies. By bringing together climate scientists and policy makers, APCS aims to bridge these gaps through discussion of cutting edge science, sharing of best practices, and the advancement of policy. This year food security, as a priority topic for Peru, was selected due to the important relationship between climate science and agriculture and fisheries.

As industries are highly dependent on climate variability, agriculture and fisheries around the world face significant threat from the impacts of climate change. Studies by academics and international organizations such as the Asian Development Bank (ADB) predict that these impacts will be increasingly disruptive to food supplies and, without sufficient preparation, may destabilize industries and potentially trigger decreased food availability. While the importance of agriculture and global environmental change is widely recognized, there are significant gaps in the policies and technical capacity of many APEC economies to build cross-industry climate resilience. With the advancement of climate prediction technology, enhanced comprehension of market response to climatic events, and improved monitoring systems, we are now capable of seriously addressing these risks. The APEC Climate Symposium 2016 will explore how changing climate affects agricultural production and investigate how climate technology can be employed in finding climate-smart agriculture and fishery solutions.

2016 APCS will feature sessions on current challenges for food security, applications of climate science for short- and long-term planning, long-term solutions for threatened fisheries, and current application challenges to linking climate information with target sectors. It will also feature a final panel discussion to wrap-up the symposium and articulate policy recommendations to APEC economies.

Session Descriptions

Opening

Current Challenges for Food Security (keynote presentation)

Climate change is already affecting food security and the most vulnerable livelihoods. Overcoming climate change is the key to food security and sustainable development. Climate change directly impacts food security as well as the underlying natural resources base, especially in fragile ecosystems, that is agriculture and fishing industry. We need to take definite action to minimize the threat of climate change to food security. Through the first session, the keynote presenters will give an overview of current challenges that the stakeholders in agriculture and fishery practitioners are facing.

Session I

Utilizing Climate Science in Agriculture: Impacts of Extreme Weather Events and Seasonal Phenomena on Agriculture

Increased climate variability and extreme weather events due to climate change have important effects on the agricultural systems of the Asia-Pacific region, with small communities of developing economies being most vulnerable to these changes. Seasonal climatic phenomena like the El Niño–Southern Oscillation have significant impacts on regional food security, particularly through extreme weather events such as droughts and floods. While there are still great challenges to solve, recent improvements in climate monitoring and observation systems increases the ability for agricultural decision-makers to respond intelligently to and manage extreme weather and climatic events. Thus, promoting climate science based agricultural policies on extreme weather events and adopting innovative technologies of climate-smart agriculture are essential next steps required for achieving sustainable agriculture and food production in the region. This session will therefore focus on the role that climate science can play in defining short-term to seasonal agricultural decisions.

Session II

Employing Climate Science for Long-Term Agricultural Planning

Food security issues in emerging economies in the APEC region will be exacerbated by theimpacts of climate change. These effects go beyond extreme weather events discussed in Session 1 and may include significant shifts in meteorological patterns, resulting in other large-scale changes in agricultural sectors. While this is recognized as integral information for sustainable agriculture and food security, there are still significant gaps in translating climate information from scenarios into long-term agricultural policy development, particularly on a local scale. Many economies lack the awareness or capacity to reap the benefits from advances in climate modelling and downscaling.

Exploring the challenges and opportunities in long-term agricultural planning will help bridge this gap, thus facilitating the use of climate information by policy-makers. This session will therefore compliment Session 1 by examining the practical application of climate science for long-term agricultural planning, with the intention of bridging gaps between science and policy.

Session III Long-term solutions for fisheries vulnerable to climate change

Rising ocean temperature and acidity rapidly alters aquatic ecosystems. These threaten marine organisms and fisheries by affecting fish habitats, production and distribution. Fishing industries of APEC economies, especially developing counties, are at risk and proper decision on policy should be made immediately for continuous economic growth. In this session, current issues of fisheries in the present days and future by climate change will be introduced and long-term solutions to maintain healthy ocean ecosystems and hence to mitigate food security will be discussed.

Panel Discussion

Each year, APCS hosts a panel discussion between leading scientists and experienced practitioners to explore additional perspectives on the symposium's key topics. The panel often highlights the importance of proactively addressing climate change in a way that is relevant to the heterogeneous mix of participants, addressing questions with important implications for government, society, and academia. Recognizing the need for complex and interdisciplinary approaches to climate issues, the panel is composed of an equally diverse range of experts. The interplay between panelists, who draw upon a veritable wealth of knowledge, provides an important opportunity for participants to gain an understanding of the diverse perspectives present in the field of food security.

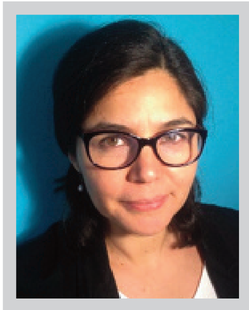
This year's panel will explore how science and technology can be employed to strengthen regional food security and provide insight into developing relevant scientific and socioeconomic policy. Other aspects of agriculture and fisheries will be discussed, with possible topics including how to build more robust, informed food supply chains and how to equip decision-makers with the climate science needed for long-term planning.

Speakers

Dr. Ana María Loboguerrero

CGIAR Research Program for Climate Change, Agriculture and Food Security

Dr. Ana María Loboguerrero is the leader of the Latin American program of the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS). In this position, she plays a major role in partnership development aimed to build impact pathways so that knowledge in climate change leads to implementation. Dr. Loboguerrero has 7 years' experience of working on climate change challenges. Previously, she worked at the Sustainable Environmental Development Deputy Directorate of the National Planning Department of Colombia as coordinator of climate change. While at the deputy directorate, Dr. Loboguerrero led the formulation of the Colombian Climate Change Policy, the National Adaptation Plan, the National Development Plan and the research agenda on climate change as well as coordinated technical support for the Colombian Low Carbon Growth Strategy. Dr. Loboguerrero has also worked as an external expert panel member of the evaluation of FAO work in climate change mitigation and adaptation.



Ms. Laura Meza

Food and Agriculture Organization of the United Nations

Ms. Laura Meza is an agronomist, with Master in Environmental Science (MSc - State University of New York) and International Relations (MA - Syracuse University). She has more than 15 years of professional experience as a researcher and expert in natural resource management and the environment. She has advised environmental management agencies such as the International Union for Conservation of Nature (IUCN), Conservation International (CI), and the Inter-American Development Bank (IDB) based on Washington D.C. and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). Since 2008 Ms. Meza has given support to the Office for Latin America and the Caribbean Organization United Nations Food and Agriculture Organization (FAO) on issues related to adaptation systems of production and design support agricultural policies around change climate. She has supported various processes of confrontation of climate change Colombia, Bolivia, Uruguay, Peru, Chile, Costa Rica, Panama, Nicaragua, among others.

Prof. Elwynn Taylor

Iowa State University

Prof. Sterling Elwynn Taylor, born 12 March 1942, grew up in Logan, Utah, graduated from South Cache High School in Hyrum, Utah, received a B.S. degree from Utah State University, Logan, Utah, and a Ph.D. from Washington University, St. Louis, Missouri.

In 1979 he accepted an appointment as the nation's first USDA Extension Climatologist. He led the effort that in 1981 established the first known automated reporting weather observation network for agriculture and received the "Raymond and Mary Baker Agronomic Excellence" award. In 2000 the Iowa Board of Regents "Award for Faculty Excellence" recognized his contribution to the goals and purposes of the State of Iowa university system. Dr. Taylor is well known internationally for his delivery of educational programs to aid in the management of risk associated with weather in agricultural production and associated economic market responses. He was a 2003 recipient of the Iowa Farm Bureau Distinguished Service to Agriculture award. He was the 2014 recipient of the national Hertz: Service to Agriculture Award from the American Association of Farm Managers and Rural Appraisers organization.

Dr. Ken Takahashi

Geophysical Institute of Peru (IGP)

Dr. Ken Takahashi is a Peruvian scientist and with a degree in physics from the Catholic University of Peru. He obtained a Ph.D. in atmospheric sciences from the University of Washington in Seattle, specializing in large-scale ocean-atmosphere interactions. After this, he was a postdoctoral researcher at Princeton University and the NOAA Geophysical Fluid Dynamics Laboratory working on large-scale climate change physics.

He returned to Peru in 2009, and is currently a research scientist and director of Atmosphere and Hydrosphere Sciences at the Geophysical Institute of Peru. His research focuses primarily on the mechanisms of El Niño-Southern Oscillation, with emphasis in its prediction, and was the scientific coordinator of the ENFEN Committee, which is the multi-institutional Peruvian government entity that issues the official ENSO outlooks, during the recent 2015-2016 El Niño. He is also a member of the CLIVAR Pacific Region Panel and of the Scientific Committee of the Tropical Pacific Observing System 2020 (TPOS 2020) project, as well as co-chair of the TPOS 2020 Eastern Pacific Task Team.

Speakers

Dr. Govindarajalu Srinivasan

Regional Integrated Multi-hazard Early warning System (RIMES)

As Chief Scientist for Climate Applications, Dr. Govindarajalu Srinivasan's work focuses on climate analysis to understand risks to societal systems, and development of decision support tools. He leads investigations on climate variability, trends, and change; and identifies risks posed to societal systems. He provides expert assistance to National Meteorological and Hydrological Services to deliver user-demanded climate data, products, and tools. He facilitates capacity building of users for application of climate information in planning and decision-making processes. Dr. Srinivasan has worked as a Consultant, Climate Adaptation and Prediction branch, World Meteorological Organization (WMO); Program Manager, Climate Change, Ministry of Earth Sciences &; Scientist, Dept. of Science & Technology (DST), Govt of India; Director, Climate Unit, India Meteorological Department; and the Asian Disaster Preparedness Center prior to his engagement with RIMES. He has more than 25 years experience in research and operational aspects of climate information, applications and services. He has represented India at UNFCCC and IPCC meetings and been involved in policy issues of climate change. He has served on the editorial board of the international journals - Agricultural and Forest Meteorology & Climate Research. He has also been a contributing author and expert reviewer for the IPCC AR4 and earlier reports. Dr. Srinivasan holds a Doctoral Degree in Atmospheric Sciences from Indian Institute of Technology, Delhi and carried out postdoctoral work at the Climate Research Unit (CRU), University of East Anglia, U.K., and the School of Environmental Sciences, Rutgers State University of New Jersey, USA.

Dr. Julian Ramirez-Villegas

International Center for Tropical Agriculture (CIAT)

Dr. Julian Ramirez-Villegas is a climate impacts scientist at the International Center for Tropical Agriculture (CIAT) in Colombia, and a research fellow at the University of Leeds in the UK. Julian is an agricultural engineer by training, with a PhD in environmental science. He has worked on a variety of projects ranging from the conservation of crop wild relatives to the projection of climate change impacts and adaptation and climate-smart agriculture, using a range of modelling tools. During his career, Julian has published more than 40 peer-reviewed papers related to crop-climate modelling, climate change impacts, adaptation, conservation of biodiversity and plant genetic resources. Julian's current research focuses on agricultural adaptation to climate change using crop and climate models, on quantifying crop-climate modelling uncertainties, and on developing an evidence base for climate-smart agriculture.

Dr. Alexander Ruane

NASA Goddard Institute for Space Studies
(Climate Impacts Group)

Dr. Alex C. Ruane is a Research Physical Scientist at the NASA Goddard Institute for Space Studies (GISS) in New York City. He earned a B.S. in Atmospheric Science from Cornell University and a Ph.D. in Climate Science at the Scripps Institution of Oceanography at the University of California, San Diego, before pursuing postdoctoral work at GISS. Dr. Ruane is a civil servant in the GISS Climate Impacts Group with a mandate to demonstrate the practical use of climate observations and climate change information, often through innovative, multi-disciplinary, multi-scale, and multi-method approaches.

Dr. Ruane's research involves the tailoring of climate scenarios for application to a wide variety of climate impacts assessments, facilitating the identification and prioritization of adaptation options for climate variability and change. He is the Science Coordinator and head of the Climate Team for the Agricultural Model Intercomparison and Improvement Project (AgMIP), an international effort involving more than 850 experts in the agricultural modeling community to link climate, crop, livestock, economics, nutrition, and food security models for consistent assessment and intercomparison of climate impacts on the agricultural sector. Dr. Ruane is active in several panels of panels of the US Global Change Research Program (USGCRP). He also founded and co-Chairs the Vulnerability, Impacts, Adaptation, and Climate Services (VIACS) Advisory Board for the sixth Phase of the Coupled Model Intercomparison Project (CMIP6), which forms a bridge between the climate modeling community and the diverse communities undertaking climate applications. Dr. Ruane has also published extensively on the representation of hydroclimate in models, and has collaborated on urban impacts assessments for New York City and the Northeast Urban Corridor.

Dr. Kwanghyung Kim

APEC Climate Center

Dr. Kwanghyung Kim joined APCC in February 2013 as a Research Fellow. Before coming to APCC, he worked as a researcher at the Samsung Advanced Institute of Technology and Samsung Techwin, where he developed molecular diagnostic assays that simultaneously detect and quantify human infectious microorganisms. He received his Ph.D. in Biological Sciences from Virginia Tech, USA, followed by a year of postdoctoral work at the Virginia Bioinformatics Institute. His Ph.D. and postdoctoral research focused on understanding a specific pathosystem in the interaction between plant or human hosts and microbial pathogens at a molecular and genomic level and dealt with the Alternaria disease of major crop plants, the human Aspergillosis disease, and allergy/asthma caused by air-born fungi. At APCC, his research goal is to systematically estimate plant and/or human infectious diseases under the ongoing effects of climate change through the sophisticated integration of pathological and ecological (biotic) information, as well as abiotic data. To accomplish his goal, he will first focus on the generation of individual pathosystem information in response to different climate change-related stressors at the genomic and physiological levels, which will later be followed by the utilization of microclimate pathosystem information, such as modules for inclusion in larger modeling systems.

Speakers

Dr. Roberto Quiroz

International Potato Center (CIP)

Dr. Roberto Quiroz has been working for the International Potato Center (CIP) since February 1996. He led the creation of the Production Systems and Environment research group and has pioneered research on climate-agriculture interactions at the Center. Roberto was one of the founders of the Consortium for the Sustainable Development of the Andes (CONDESAN) and he led the Global Mountain Program: a CGIAR initiative created to promote sustainable agriculture in mountain areas. Roberto has served in many capacities including project leader and division leader. He currently leads the Crop Systems Intensification and Climate Change Disciplinary Center of Excellence. Roberto has MS and PhD degrees from North Carolina State University in nutrition and biochemistry and over 30 years of field experience putting science at the service of people. He has experience conducting and leading basic and translational research – to understand the interaction between climate and agriculture and how farmers can cope and adapt to extreme events – in the Americas, Asia and Africa. He also took a four-month sabbatical to work with the radar group of the Jet Propulsion Laboratory of the US National Air and Space Administration (JPL-NASA).Roberto has published extensively in scientific journals and has been a speaker at many international events. Throughout his career, he has also dedicated time to teach and mentor young scientists, which he hopes to do for the rest of his life.

Dr. Toshichika Iizumi

National Agriculture and Food Research Organization (NARO), Japan

Dr. Toshichika Iizumi is Senior Researcher at the Institute for Agro-Environmental Sciences, a center for research on agricultural impact of climate change and adaptation in the NARO. His global crop study aims to understand how changes in management and climate have contributed to crop production in the historical past and its application to depict food production pathways in coming decades under changing climate. Using global crop models, climate change projections, seasonal climate forecasts, statistical downscaling and data assimilation techniques, his research ultimately aims to aid in transforming crop production systems into more climate-smart ones. He was Associate Editor of Journal of Agricultural Meteorology, and is Editor of Climate Research. He won The Young Scientists' Prize of the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology of Japan in 2015.

Prof. Mark Howden

Australian National University

Prof. Mark Howden is Director of the Climate Change Institute at the Australian National University. His work has focussed on climate impacts and adaptation for systems we value: agriculture and food security, the natural resource base, ecosystems and biodiversity, energy, water and urban systems. He helped develop the national and international greenhouse gas inventories and has assessed sustainable ways to reduce emissions. Mark has partnered with many industry, community and policy groups via both research and science-policy roles and has over 400 publications. He has been a major contributor to the IPCC since 1991 now being a Vice Chair of IPCC Working Group 2.

Dr. Ho-Young Kwon

International Food Policy Research Institute

Dr. Ho-Young Kwon, a Research Fellow of the Environment and Production Technology Division, received his Masters in Environmental Management from Duke University at Durham, NC and PhD in Environmental Sciences from University of Illinois at Urbana-Champaign, IL. Prior to joining IFPRI in March 2013, he worked as a Postdoctoral Associate at University of Florida and University of Illinois on developing process-based modeling frameworks that link to policy and econometric models. His research has focused on incorporation of up-to-date findings about soil-plant-nutrient interactions into process-based modeling frameworks where global statistics databases and remote sensing data/analyses coupled with models are designed to investigate sustainable management strategies and current environmental issues. He has been involved in several projects, including Economics of Land Degradation initiative (ZEF), Low Emission Development Strategies (USAID), and Soil Carbon Emission Associated with Land Use Conversion for Cellulosic Ethanol Production (USDOE).

Dr. Maximo Torero

International Food Policy Research Institute

Dr. Maximo Torero is the Division Director of the Markets, Trade, and Institutions Division at the International Food Policy Research Institute, leader of the Global Research Program on Institutions and Infrastructure for Market Development and Director for Latin America. He has fifteen years of experience in applied research and in operational activities. In this capacity as director and research program leader, he directs the activities of an IFPRI unit that conducts research, with special emphasis on M&E of infrastructure and rural development interventions in urban and peri-urban areas through the use of randomized experimental design. Prior to that, he was a senior researcher and member of the executive committee at Group of Analysis for Development (GRADE). He received his Ph.D. from the University of California at Los Angeles Department of Economics, is a professor on leave at the Universidad del Pacífico, was postdoctoral fellow at the UCLA Institute for Social Science Research (ISSR), and an Alexander von Humboldt Fellow at University of Bonn, Germany. Dr. Torero's major research work lies mostly in analyzing poverty, inequality, importance of geography and assets (private or public) in explaining poverty, and in policies oriented towards poverty alleviation based on the role played by infrastructure, institutions, and on how technological breakthroughs (or discontinuities) can improve the welfare of households. His experience extends to projects in Latin America, Sub Saharan Africa (east and West), and Asia. Dr. Torero had a unique expertise on impact evaluation on projects linked to water and sanitation, electricity, ICTs, roads, and in social and institutional aspects on the delivery of public services. He has won twice the World Award for Outstanding Research on Development given by the Global Development Network (GDN).

Dr. Willingthon Pavan

University of Passo Fundo, Brazil

Dr. Willingthon Pavan is a full professor at Graduate Program in Applied Computing of University of Passo Fundo, Brazil. Is a computer science scientist with experience in academia and development of tools for the agricultural area. Expertise in the development of disease simulation models, systems for aid in taking decisions, and software development for small equipments. Is graduated in Computer Science by University of Passo Fundo (1994), master in Computer Science by Federal University of Rio Grande do Sul (2000), Ph.D. in Agronomy (Phytopathology) by University of Passo Fundo (2007), and postdoctorate by University of Florida (2008-2009). Has experience in Computer Science and Agronomy, focusing on Analytical Models and Simulation, acting on the following subjects: mathematical models, simulation, and programming languages.

Dr. David Ellis

International Potato Center (CIP)

Dr. David Ellis, Leader of the Program for the Conservation of Biodiversity for the Future of the International Potato Center (CIP) has been involved in the preservation of plant genetic resources for decades, with experience in academia, private industry and the public sector. Dave is currently charged with overseeing the maintenance of the global in-trust collections of potato, sweetpotato and Andean root and tuber crops in the CIP Genebank, in Lima, Peru.

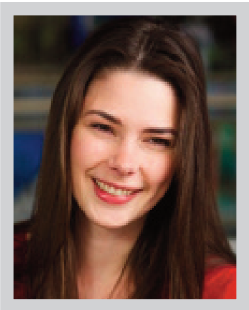
With a PhD in Botany from the University of Montana, USA, Dave's research interests have spanned plant development, medicinal compounds in plants (taxol), plant molecular biology (modification of plant cell walls, control of plant reproduction, genomics), plant and insect ecology, cryobiology and conservation of plant genetic resources and diversity. His expertise in heading programs for the conservation of plant and microbial genetic resources and running genebanks brought him to CIP in 2012.

Dave has collaborated with the International Maize and Wheat Improvement Center (CIMMYT) in the collection of teosinte (the immediate ancestor to maize) in Mexico, worked with native American tribes in the U.S. to preserve their plant genetic resources (principally Fraxinus (ash) seed), and is currently working with indigenous communities in the Potato Park (Parque de la Papa), in the Peruvian Andes. Dave has been a member of the Advisory Board for the Desert Legume Program, an associate editor of In Vitro Cellular & Developmental Biology – Plant, board member of the Society for In Vitro Biology, and a fellow of the Society for In Vitro Biology. He is currently a member of the scientific advisory committees for Asociación ANDES and SeedSavers. He has published extensively in peer review journals, book chapters and conference proceedings.

Eng. Grinia J. Avalos Roldán

National Meteorology and Hydrology Service of Peru (SENAMHI)

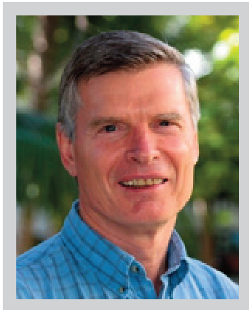
Meteorologist engineer graduated from the Universidad Nacional Agraria La Molina with a Master Degree in Applied Meteorology (completed studies) -UNALM. Specialized studies in numerical modeling at the University of Maryland - USA (2000-2001); training in physical parametrizations and in settings of the Eta - CPTEC-Brazil model (2004); Diploma course on Administration and Management for Engineers organized by the Universidad Nacional de San Marcos (2007); Diploma course on Risk Management to face Climate Change, organized by the Ricardo Palma University (2008); Training in the implementation of a high-resolution model for generating climate change scenarios in the Andean region in the Meteorological Research Institute - MRI of Japan (2007 and 2008); Formulation and coordination of climate component of the PRAA Project (Adaptation to the accelerated glacier retreat in the Andean tropical glacier Project) with the financial support from the World Bank and the coordination of the CAN (2007-2008; 2009-2011). She has participated as a speaker in various scientific meetings in public and private institutions. Since 1998, she worked for SENAMHI as professional of the General Directorate of Meteorology. In 2012, Eng. Roldán was promoted to the position of Director of Applied Meteorology and between 2013 and 2016 I have been in charge of the Directorate of Climatology. As of May 26, 2016 she is working as Deputy Director of Climate Prediction of the Directorate of Meteorology and Atmospheric and Environmental Assessment office of SENAMHI. Eng. Roldán is SENAMHI's technical representative with the ENFEN (National Study of the El Niño Phenomenon) and is currently technical coordinator of the Climandes Project one of the projects prioritized by WMO for the implementation of the Global Framework for Climate Services. She is a member of the Global Task Team for Seasonal Climate Update of the Commission for Climatology of the World Meteorological Organization.



Ms. Lauren Weatherdon

Marine Programme, UNEP World Conservation Monitoring Centre

Ms. Lauren Weatherdon is a Programme Officer in the Marine Programme at the UNEP World Conservation Monitoring Centre (UNEP-WCMC), which is a collaboration between the not-for-profit organisation, WCMC, and the United Nations Environment Programme to deliver specialist biodiversity expertise. As part of her role, she streamlines marine and coastal data to support decision-making and efforts to track progress towards global conservation targets. Her areas of expertise include fisheries management, spatial ecology (species and habitat distribution mapping and modelling), and climate change (impacts and adaptation). Previously, she collaborated with scientists under the "Oceans 2015 Initiative" to produce a review of the scientific literature published subsequent to the IPCC's Fifth Assessment Report, identifying points of agreement and departure regarding the impacts of climate change on coastal sectors through changes in the marine environment. She has also led research on the impacts of climate change on fisheries catch potential for coastal indigenous communities of British Columbia, Canada.



Dr. Johann Bell

Conservation International

Dr. Johann Bell has worked extensively on fisheries and aquaculture in developing countries in Asia-Pacific with WorldFish and the Pacific Community. In recent years, he has focused on the strategic planning needed to maintain the important role that fish plays in the food security of Pacific Island countries in the face of rapid population growth and climate change.

While Dr. Bell was employed at the Pacific Community, he led a major assessment of the vulnerability of fisheries and aquaculture in the tropical Pacific to climate change and was a contributing author to Chapter 30 (The Ocean) of the Intergovernmental Panel on Climate Change Fifth Assessment Report. More recently, Johann has advised the Consultative Group on International Agricultural Research's cooperative research program on 'Climate Change, Agriculture and Food Security' about building climate-resilient food systems for Pacific Islands.

Dr. Bell currently works as a consultant for Conservation International's 'Tuna Initiative' and has contributed to the development of policies to diversify the use of tuna to improve food security and public health in Pacific Island countries. Johann is also a Visiting Professorial Fellow at the Australian National Centre for Ocean Resources and Security, University of Wollongong (http://ancors.uow.edu.au/fellows/UOW189534.html), the Chair the Recreational Fishing Advisory Council for the State of NSW in Australia, and a member of the International Advisory Committee for the United Nation University's Institute of Water, Environment and Health.

Dr. Elvira Poloczanska

Alfred Wegener Institute
(Biosciences | Integrative Ecophysiology)

Prof. Elvira Poloczanska has over 15 years experience in climate change research with a background in marine ecology and fisheries modelling. Her work includes syntheses and modelling of responses of marine biodiversity to climate change at local, regional and global scales. Her research also focuses on understanding adaptation options to climate change for marine management and fisheries. Elvira was a senior scientist with CSIRO Oceans and Atmosphere, Australia, for 11 years and has recently moved to the Alfred Wegener Institute, Germany, as Director of Science in the Technical Support Unit of Working Group II of the Intergovernmental Panel on climate Change.

Dr. Dimitri Gutierrez Aguilar

Ocean Institute of Peru (IMARPE)

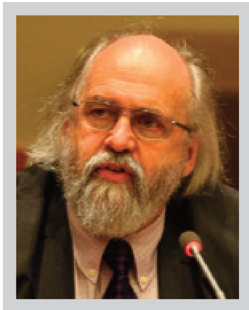
Dr. Dimitri Gutiérrez, a Peruvian biological oceanographer, is the Director of Research in Oceanography and Climate Change of the Peruvian Marine Research Institute (IMARPE) since 2012. His research has been focused on paleoceanography of the Peruvian upwelling ecosystem, recent trends and global warming impacts on the upwelling ecosystem, oxygen minimum zone and benthic communities. He is author or co-author of over 60 publications in scientific journals and books. He is currently involved in adaptation projects for the impact of climate change on Peruvian fisheries and marine coastal ecosystems.

Speakers

Dr. Ussif Rashid Sumaila

University of British Columbia

Dr. Sumaila is Professor at the Institute for the Oceans & Fisheries and the Liu Institute for Global Issues, and Director of the Fisheries Economics Research Unit (FERU) at the University of British Columbia. He specializes in bioeconomics, marine ecosystem valuation and the analysis of global issues such as fisheries subsidies, IUU (illegal, unreported and unregulated) fishing, and the economics of high and deep seas fisheries. Dr. Sumaila has experience working in fisheries and natural resource projects in Canada and the North Atlantic region, Norway, Namibia and the Southern African region, Ghana and the West African region, and Hong Kong and the South China Sea. He has authored over 180 journal articles; including in Science and Nature. Sumaila is the winner of the 2013 American Fisheries Society Excellence in Public Outreach, the Stanford Leopold Leadership Fellowship and the Pew Marine Fellowship. He has given talks at the UN Rio+20, the WTO, the White House, the Canadian Parliament and the British House of Lords. His research has generated a great deal of interest, and has been cited by, among others, The Economist, The Boston Globe, International Herald Tribune, the Globe and Mail, the Wall Street Journal and Vancouver Sun.



Dr. Jake Rice

Department of Fisheries and Oceans Canada

Dr. Jake Rice retired in 2015 after 9 years as Chief Scientist for the Department of Fisheries and Oceans, Canada. He previously served as Director of Peer Review and Science Advice (1996-2006) and held senior DFO Science positions in Pacific (1990-1996) and Newfoundland Regions (1982-1990). He received a BSc. from Cornell University (1970 - Conservation) and a Ph. D. from University of Toronto (1974 - Ornithology). He has more than 300 publications in the scientific and technical literature, primarily on the ecosystem approach to integrated marine resource management and the science-policy interface in natural resource management and conservation. In 2014 a book Governance of Marine Fisheries and Biodiversity Conservation, co-edited with Serge Garcia and Tony Charles, was published by Wiley.

He co-chairs the Regional Assessment for "the Americas" for the Intergovernmental Panel on Biodiversity and Ecosystem Services, was a member of the Group of Experts for the UN Regular Process for Global Marine Assessments overseeing the First World Ocean Assessment, and was a Lead Author for the chapter on Drivers, Trends and Mitigation, for the IPCC 5th Assessment Report. He has been active as an expert or delegate to an alphabet soup of UN meetings and agencies (FAO, CBD, GEF, UNEP, UNESCO-IOC, ICP, BBNJ etc), and served as the Canadian member of the ICES Advisory Committee on Fisheries Management, and later the Advisory Committee on Ecosystems from 1996-2008.

Program

Friday September 16, 2016		APEC Climate Symposium 2016
08:00-09:00	**Registration**	
09:00-10:00	**Opening Ceremony**	**MC: Ms. Sangwon Moon** Head of External Affairs Department, APEC Climate Center
09:00-09:10	Opening Remarks	**Dr. Hong-Sang Jung** Executive Director, APEC Climate Center
09:10-09:20	Opening Remarks	**Eng. Amelia Ysabel Díaz Pablo** Executive President, National Meteorology and Hydrology Service of Peru (SENAMHI)
09:20-09:30	Congratulatory Address	**Mr. Keun Ho Jang** Ambassador of the Republic of Korea to Peru
09:30-09:40	Welcome Remarks	**Mr. Marcos Gabriel Alegre Chang** Vice Minister, Environmental Management Division, Ministry of Environment of Peru
09:40-10:00	**Commemorative Plaque Presentation and Photo Session**	
10:00-10:20	**Coffee Break**	
10:20-12:00	**Keynote Session** Keynote Presentations	**Chair: Dr. Jin Ho Yoo** **Rapporteur: Ms. Christianne Aikins**
10:20-11:00	Reducing risks to food security from climate change	**Dr. Ana María Loboguerrero Rodriguez** CGIAR Research Program for Climate Change, Agriculture and Food Security
11:00-11:40	Climate change and food security: policy recommendations	**Ms. Laura Meza** Food and Agriculture Organization of the United Nations – Regional Office for Latin America and the Caribbean
11:40-12:00	**Wrap-up and Discussion**	
12:00-13:00	**Luncheon**	
13:00-18:00	**Session I** Utilizing Climate Science in Agriculture: Impacts of Extreme Weather and Climate Events on Agriculture	**Chair: Dr. Alexander C. Ruane** **Rapporteur: Julian Ramirez-Villegas**
13:00-13:30	Subtle climate shift, major agricultural impact	**Prof. Elwynn Taylor** Iowa State University
13:30-14:00	Prediction of El Niño/La Niña, their diversity and climate impacts in Peru	**Dr. Ken Takahashi** Geophysical Institute of Peru (IGP)
14:00-14:30	Operationalizing the use of weather and climate information for agriculture in Asia	**Dr. Govindarajalu Srinivasan** Regional Integrated Multi-Hazard Early Warning System (RIMES)
14:30-15:00	Using crop-climate modelling for adapting cropping systems to climate variability	**Dr. Julian Ramirez-Villegas** International Center for Tropical Agriculture (CIAT)
15:00-15:30	**Coffee Break**	
15:30-16:00	Climate application for agriculture and food security	**Dr. Alexander C. Ruane** Climate Impacts Group, NASA GISS
16:00-16:30	Improving agricultural resilience to climate variability through ensuring data availability and enhancing agro-meteorological services	**Dr. Kwanghyung Kim** APEC Climate Center
16:30-17:00	Assessing the impact of climate change on potato cultivation in its center of origin	**Dr. Roberto Quiroz** International Potato Center (CIP)
17:00-18:00	**Wrap-up and Discussion**	
18:30-20:00	**Welcome Cocktail Reception hosted by SENAMHI**	

Program

Saturday September 17, 2016		APEC Climate Symposium 2016
09:00-14:50	**Session II** **Employing Climate Science for Long-Term Agricultural Planning**	**Chair: Dr. Maximo Torero** **Rapporteur: Ho Young Kwon**
09:00-09:30	Growth and variability of crop production under climate change and socioeconomic pathways	**Dr. Toshichika Iizumi** National Agriculture and Food Research Organization(NARO), Japan
09:30-10:00	Seasonal climate forecasts as a pathway for climate change adaptation: a review	**Dr. Mark Howden** Australian National University
10:00-10:30	Global adoption of climate-smart agriculture: ex-ante economic impact assessment	**Dr. Ho-Young Kwon** International Food Policy Research Institute
10:30-10:50	**Coffee Break**	
10:50-11:20	Scenarios on climate change impacts for developing APEC economies and how to increase resilience and benefit from opportunities	**Dr. Maximo Torero** International Food Policy Research Institute
11:20-11:50	Climate information tools for decision making	**Dr. Willingthon Pavan** University of Passo Fundo, Brazil
11:50-12:50	**Luncheon**	
12:50-13:20	Is agrobiodiversity a key to sustainable crop production in a changing environment?	**Dr. David Ellis** International Potato Center (CIP)
13:20-13:50	Implementing climate information services for decision-making in Peru	**Eng. Grinia J. Avalos Roldán** National Meteorology and Hydrology Service of Peru (SENAMHI)
13:50-14:50	**Wrap-up and Discussion**	
14:50-15:00	**Break**	
15:00-19:00	**Session III** **Long-term Solutions for Threatened Fisheries Caused by Climate Change**	**Chair: Dr. Johann Bell** **Rapporteur: Ms. Lauren Weatherdon**
15:00-15:30	Where are the fish? Reducing climate impacts on coastal communities and marine industry	**Ms. Lauren V. Weatherdon** UNEP World Conservation Monitoring Centre
15:30-16:00	The effects of climate change on the contributions of fisheries and aquaculture to food security	**Dr. Johann Bell** Conservation International
16:00-16:30	Current and future situation of Australian fisheries to climate change	**Prof. Elvira Poloczanska** Alfred Wegener Institute (Biosciences | Integrative Ecophysiology)
16:30-16:50	**Coffee Break**	
16:50-17:20	Productivity and sustainable management of the humboldt current large marine ecosystem	**Dr. Dimitri Gutiérrez** Ocean Institute of Peru (IMARPE)
17:20-17:50	Climate change effects on the economics and management of world fisheries	**Dr. Rashid Sumaila** University of British Columbia
17:50-18:20	Climate change, food security, and the ocean: is there a path forward?	**Dr. Jake Rice** Department of Fisheries and Oceans Canada
18:20-19:20	**Wrap-up and Discussion**	

Program

Sunday September 18, 2016		APEC Climate Symposium 2016
09:00-12:00	**Session IV** Wrap-up and Panel Discussion	**Chair: Dr. Mark Howden** **Rapporteur: Ms. Christianne Aikins**
09:00-09:30	Session I Wrap-up	**Dr. Alexander C. Ruane** Climate Impacts Group, NASA GISS
09:30-10:00	Session II Wrap-up	**Dr. Maximo Torero** International Food Policy Research Institute
10:00-10:30	Session III Wrap-up	**Dr. Johann Bell** Conservation International
10:30-10:45	**Coffee Break**	
10:45-11:40	**Panel Discussion**	**Dr. Mark Howden** Australian National University **Dr. Heekyung Park** Korea Advanced Institute of Science and Technology **Prof. Elwynn Taylor** Iowa State University **Dr. Maximo Torero** International Food Policy Research Center **Dr. Dimitri Gutiérrez** Ocean Institute of Peru (IMARPE) **Dr. Waldo Lavado** National Meteorology and Hydrology Service of Peru (SENAMHI)
11:40-12:00	**Closing**	
12:00-13:00	**Luncheon**	

1

Session I

Utilizing Climate Science in Agriculture: Impacts of Extreme Weather and Climate events on Agriculture

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SUBTLE CLIMATE SHIFT, MAJOR AGRICULTURAL IMPACT

Prof. Elwynn Taylor
Iowa State University

PREDICTION OF EL NINO/LA NINA, THEIR DIVERSITY AND CLIMATE IMPACTS IN PERU

Dr. Ken Takahashi
Geophysical Institute of Peru (IGP)

OPERATIONALIZING THE USE OF WEATHER AND CLIMATE INFORMATION FOR AGRICULTURE IN ASIA

Dr. Govindarajalu Srinivasan
Regional Integrated Multi-hazard Early warning System (RIMES)

USING CROP-CLIMATE MODELLING FOR ADAPTING CROP-PING SYSTEMS TO CLIMATE VARIABILITY

Dr. Julian Ramirez-Villegas
International Center for Tropical Agriculture (CIAT)

CLIMATE APPLICATION FOR AGRICULTURE AND FOOD SECURITY

Dr. Alexander Ruane
NASA Goddard Institute for Space Studies (Climate Impacts Group)

IMPROVING AGRICULTURAL RESILIENCE TO CLIMATE VARIABILITY AND ENHANCING AGRO-METEOROLOGICAL SERVICIES

Dr. Kwanghyung Kim
APEC Climate Center (APCC)

ASSESSING THE IMPACT OF CLIMATE CHANGE ON POTATO CULTIVATION IN ITS CENTER OF ORIGIN

Dr. Roberto Quiroz
International Potato Center (CIP)

APEC Climate Symposium 2016

Smart Climate Information and Accountable Action:

Achieving Sustainable Food Security in a Changing World

SUBTLE CLIMATE SHIFT, MAJOR AGRICULTURAL IMPACT

Prof. Elwynn Taylor
Iowa State University

Epoch storms, drought, and flood make headline news. Diminished diurnal temperature range is hardly noticed and accompanying annual reduction of crop yield, hardly dramatic in any given year, quietly impacts the world. The changing occurrence of tropical storms may be cyclic or associated with a changing atmospheric climate. The impact of great storms is sudden and often disastrous. The impact of an overnight temperature shift of one degree Celsius may go unnoticed as the cause of a long-term drop in food production. The impact on economies and on the welfare of millions of people may greatly exceed the total impact of the changing nature of major storms.

PREDICTION OF EL NIÑO/LA NIÑA, THEIR DIVERSITY AND CLIMATE IMPACTS IN PERU

Dr. Ken Takahashi

Geophysical Institute of Peru (IGP)

El Niño was originally identified as anomalous warming along the Peruvian coast that was later found to be associated with a large-scale ocean-atmosphere phenomenon in the tropical Pacific, the El Niño-Southern Oscillation (ENSO). Advances in understanding the basic physical mechanisms and numerical modeling of ENSO have increased our capacity to predict the main associated climate variations. However, El Niño and La Niña events are diverse and the climate impacts in Peru depend on the details of these, as well as on the role of other climate phenomena. Specifically, ENSO diversity can be quantified to first approximation by the longitudinal distribution of the equatorial sea surface temperature anomalies, e.g. classifying the events into Central Pacific (CP) and Eastern Pacific (EP) types, depending on where the anomalies are largest. The climate impacts of the EP El Niño events on Peru are better known, associated with coastal warming, increased sea level, intense rainfall on the arid coastal lowlands in austral summer/fall, and alteration of the marine environment that can affect its ecosystems. On the other hand, the CP El Niño has an opposing effect on rainfall, tending to reduce it in the Andes, including the middle and upper parts of the coastal river basins, and in the Amazon region. Additionally, the extreme EP El Niño events of 1982-83 and 1997-98 produced disproportionally large coastal impacts in Peru, costing up to 7% an 4.5% of the GDP, respectively, and our research suggests that the physics of these extreme events are different from the others, associated primarily with processes in the eastern Pacific. Predicting the extreme El Niño with several months in advance is a key need for decision makers, but state-of-the-art forecast models are still deficient for simulating the mean climate, particularly in the eastern Pacific (e.g. the double ITCZ syndrome), as well as ENSO diversity.

The ENFEN Committee* is the multi-institutional entity that issues the official El Niño and La Niña outlooks in Peru. Since 2012, due to the different impacts of ENSO types, the Committee explicitly distinguishes between the "coastal (EP) El Niño/La Niña" and the "central Pacific El Niño/La Niña", among which the latter is the exclusive focus of many of the international agencies world-wide due to its teleconnections (including to Peru). The Committee issues medium-range forecasts (up to 3 months) by the monitoring and modeling of equatorial ocean Kelvin waves. At longer leads, the Committee combines the analysis of basin-wide ocean-atmosphere conditions, with theoretical understanding of the dynamics of the system, as well as global climate model predictions and knowledge of their deficiencies, to produce the outlooks. Since 2015, the Committee produces probabilistic predictions of the strength of both the coastal and central Pacific El Niño and La Niña events for the austral summer due to their potential impact on rainfall. These proved to be very useful for high-level decision making in the Peruvian government, allowing for the optimization of allocation of resources during the 2015-2016 El Niño. However, the predictions had substantial uncertainties and their reduction will require substantial improvements in observations, modeling and scientific understanding in the eastern Pacific.

* *Comité Multisectorial encargado del Estudio Nacional del Fenómeno El Niño*

OPERATIONALIZING THE USE OF WEATHER AND CLIMATE INFORMATION FOR AGRICULTURE IN ASIA

Dr. Govindarajalu Srinivasan

Regional Integrated Multi-hazard Early warning System (RIMES)

Significant progress has been made during the last few decades in the area of weather and climate modelling making available predictions on a wide range of lead times. Such predictions provide sufficient advance information to adjust critical agricultural decisions, with significant potential to contribute to the efficiency of agricultural management, and to food security. Operationalizing systematic use of such information requires a well-coordinated end-to-end institutional system that begins with monitoring of weather and climate events and ends with a community level response. The main challenge of such a system would also be the customization of information to climate sensitive points of decision-making. This needs to be evolved iteratively through an interactive process of stakeholder engagement.

The need of systematic integration of weather and climate information and its particular relevance in the present times shall be highlighted in the presentation. Examples from projects being implemented in Myanmar and Tamil Nadu, India will be used to elaborate the process of operationalization. Besides close linkages between key institutions, operationalizing the use of weather and climate information requires availability of data and adequate understanding of climate sensitive aspects of the sector. The talk would bring such challenges that have to be overcome to scale up climate services for agriculture and food security.

USING CROP-CLIMATE MODELLING FOR ADAPTING CROPPING SYSTEMS TO CLIMATE VARIABILITY

Julian Ramirez-Villegas[1, 2, 3]; Diego Agudelo[1], Camilo Barrios[1]; Sylvain Delerce[1]; Hugo Dorado[1]; Diana Giraldo1; Andy Jarvis[1, 2]; Daniel Jimenez[1]; Lizeth Llanos[1]; Diego Obando[1]; Victor H. Patiño[1]; Steven D. Prager[1]; Camila Rebolledo[1]; Jeferson Rodriguez[1]; Jeimar Tapasco[1]

[1] International Center for Tropical Agriculture (CIAT), Cali, Colombia
[2] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), c/o CIAT, Cali, Colombia
[3] School of Earth and Environment, University of Leeds, Leeds, UK

Agriculture is one of the most vulnerable sectors to climatic variations; interannual climate variability explains roughly one third of the global spatio-temporal variation in the yields of maize, rice, soybeans and wheat. This is because climatic conditions affect the planning of agricultural activities in the field and the performance of crops in the field, hence conditioning the outcomes of all agricultural activities. Moreover, as the climate system responds to anthropogenic forcing, it has been projected that climate variability, including the frequency and intensity of seasonal extremes, will likely increase during the 21st century. This is true even for ambitious mitigation targets such as those of the Paris Agreement. Understanding climate variability and its impacts on farming as well as adequately responding to it are thus critical needs in agriculture. Here, we summarize results of ongoing initiatives on climate variability adaptation for Colombian agriculture that span a range of inter-related disciplines including seasonal yield forecasting, big-data-driven site-specific agriculture, and technology (varietal) testing, and involve a total of 13 different national partners across 19 out of the 32 departments of Colombia. While work focused on five crops (rice, maize, beans, bananas, cassava) across the country, we concentrate on rice systems as one of the key success stories. Findings suggest that, on average, between 28–61 % of the variability in rice crop yields at the field-scale can be explained by climate conditions alone, with drivers of climate variability often changing per site and variety. In most rice growing areas, it was possible to identify a single critical climatic limiting factor and identify what type of site-specific management would lead to increased yields. Site-specific management recommendations were then discussed and validated with local agronomists, and later provided to farmers, leading to enhanced crop system performance. Seasonal yield forecasts, varietal testing in the field, and the creation of agro-climatic roundtables, then helped to influence next season's farm-level decisions on what and when to plant across the country. While continuous testing of recommendations and evaluation of adoption levels at the sector level is further needed to appropriately assess the impact of these activities, sector-specific benefits have been substantial, with crop losses during the 2015-2016 ENSO event being avoided, yield gaps being closed and available agricultural technologies better understood and targeted.

CLIMATE APPLICATION FOR AGRICULTURE AND FOOD SECURITY

Dr. Alexander Ruane

NASA Goddard Institute for Space Studies (Climate Impacts Group)

Farmers and the broader agricultural sector have managed climate impacts for thousands of years, seeking to take advantage of fair weather years while minimizing the losses from floods, droughts, heat waves, and frosts. Today there are tremendous new technologies for sophisticated agricultural management as well as new information products that place cutting-edge science at our fingertips. These allow for new levels of risk management with a goal of sustainable, resilient, and productive food systems.

This presentation will describe climate applications for agriculture and food security stemming from farmer surveys, field experiments, and agricultural models that show us how our farm systems respond to shifts in weather and climate. Critical agricultural impacts may take place in just minutes (for example, from a particularly severe frost), over the course of a day (a strong downpour), a sequence of days (a heatwave), or extended over weeks and even years (a persistent drought). To understand these impacts on a farm we approach the problem in a risk management framework -- focusing on the probability of occurrence for a given extreme event, the exposure of the farm to the extreme conditions, and the vulnerability of the system once exposed. Once we have characterized the occurrence, vulnerability, and exposure we are able to identify opportunities for adaptation as a reduction in any of these elements benefits the stability of the entire system.

The occurrence of extreme events may be predictable either on an individual basis or through our understanding of the overall statistics of weather (which we call "climate"). We are thus able to design farming systems that anticipate extreme events, but we have to be aware that human influences are changing the Earth's climate and thus shifting the characteristics of extreme events in a given region. This may change the frequency, intensity, duration, and geographic extent of events when they occur, although climate models can help us understand the types of shifts that are occurring, but also demonstrate that society's actions on greenhouse gas mitigation can reduce the occurrence of detrimental extremes.

The extent to which farms are exposed to these extremes may be dramatically altered, for example through the construction of levees to reduce flood inundation. With forecasted warnings (of hail or heat waves, for example), livestock and sensitive crops may be placed in protected areas. Scientists have linked disease and pest outbreaks to excess moisture on plant leaves, providing opportunities to recognize and even reduce exposure to dangerous conditions before disaster strikes.

Even accepting that extreme events will affect a farm system, there is an opportunity to reduce the impact by enhancing resilience. Irrigation, shading, and flood-resistant seed cultivars are all examples of adaptation investments that allow productive agriculture to persist even in the face of extreme conditions. With accurate forecasts and agricultural models we can stress test our agricultural systems in order to identify and reduce vulnerabilities.

Recent efforts by the Agricultural Model Intercomparison and Improvement Project (AgMIP) demonstrate novel applications of climate information for agricultural planning and investment. These recognize the interconnected nature of the agricultural system, with local impacts affecting international markets and distant trading flows incentivizing local planting decisions. AgMIP models illustrate the challenges facing agriculture, allowing resilience planning even as precise prediction of extremes remains difficult. Climate applications are currently focusing on the reverberating effects of climate shocks through socioeconomic and biophysical systems, helping to recognize unintended consequences and feedback loops as decision-makers respond to the prospect of production shortfalls. Finally, we will discuss AgMIP assessments' use of cutting-edge climate products for historical data, real-time monitoring, seasonal prediction, and long-term climate projections; each with their own uncertainties.

IMPROVING AGRICULTURAL RESILIENCE TO CLIMATE VARIABILITY AND ENHANCING AGRO-METEOROLOGICAL SERVICES

Dr. Kwanghyung Kim

APEC Climate Center

Agricultural resilience requires understanding the impacts of climate variability and the dynamics of farmer adaptation. Weather and climate forecasting allows for the prediction of yields considering potential risks of crop damage and thus enables the exploration of adaptation strategies, but the challenge lies in translating low-to-moderate skill climate information into useful information for farmers. Complex climate-crop interactions are made relevant to the layperson through building easy-to-use tool kits, but these tools are only useful to end users if a decision support environment (building relationships and trust among stakeholders, continued/iterative communication in co-generating products) is created instead of only decision support systems. In fact, anyone who works in climate would recognize the disbelief encountered when talking about climate prediction to a group of people who are experiencing a deviation in weather from what was predicted. Similarly, any agricultural information translated from the climate prediction has no choice but to inherit the distrust within the stakeholder groups. Therefore there need to develop ways to effectively communicate the long-term, variable nature of such climate prediction and its agricultural information by-product. We will highlight these issues by telling the story of the long term use of climate smart agriculture. Here, climate smart agriculture refers to the smart use of climate information for agricultural decision making, which results in maximizing the positive and minimizing the negative influence of climate. Several case studies will be shared, emphasizing on how improved data availability by a stakeholder-participatory approach led to enhanced agro-met services and eventually improved agricultural resilience to climate variability in the communities.

ASSESSING THE IMPACT OF CLIMATE CHANGE ON POTATO CULTIVATION IN ITS CENTER OF ORIGIN

Dr. Roberto Quiroz
International Potato Center (CIP)

Andean farmers cope with the constant presence of extreme climatic events by diversifying their crops, managing spatial variability, stagger planting and the use of biodiversity. With the current warming trend and less reliability of rains, food security is at stake. A series of studies have been conducted by CIP and partners to develop the capacity to model how changes in key climatic variables might affect the most important staple, the potato. Crop growth and pest models were constructed and validated to assess the impact of dramatic changes in temperature, rainfall and CO2 might have on the phenology of pests, the need for chemical control and the likely effect on the yield of local and introduced varieties. The warming trend will increase the proliferation of e.g. potato tuber moth, late blight and potato yellow vein virus. It will also decrease tuber yield (4 % per oC on average) with more dramatic reductions in native when compared to introduced and hybrid varieties. Reduction or increment in rainfall (-/+ 30 % of actual) produced changes in the order of - 4.9 or +2.5 %, respectively; but in the best of the cases yields were way below their potential under irrigated conditions. The fertilization effect due to higher CO2 concentration was estimated as 10 % per 100 ppm incremented. Tolerant varieties and appropriate soil, crop, and water management are needed to guarantee food security.

APEC Climate Symposium 2016

Smart Climate Information and Accountable Action:

Achieving Sustainable Food Security in a Changing World

2

Session II

Employing Climate Science for Long-Term Agricultural Planning

APEC Climate Symposium 2016

Smart Climate Information and Accountable Action:

Achieving Sustainable Food Security in a Changing World

GROWTH AND VARIABILITY OF CROP PRODUCTION UNDER CLIMATE AND SOCIOECONOMIC PATHWAYS

Dr. Toshichika Iizumi
National Agriculture and Food Research Organization (NARO), Japan

Future projections of climate change impacts are a scientific basis in planning national adaptation and agricultural development programs in coming years. In addition to them, it has become increasing important to understand the climate change impacts on agriculture in the historical past. Studies detecting change in growth and yield across crops and regions of the world and attributing them to historical change in climate and agricultural technology offer further information for national governments and international development organizations about adaptation and development priorities.

Here, I present two recent research outcomes. The first one is the global analysis detecting yield variability change and attributing it to recent climate change. This research shows that year-to-year variations in yields of maize, soybean, rice and wheat in 1981–2010 significantly decreased in 19%–33% of the global harvested area with varying extent of area by crop. However, in 9%–22% of harvested area, significant increase in yield variability was detected. Major crop-producing regions with increased yield variability include maize and soybean in Argentina and Northeast China, rice in Indonesia and Southern China, and wheat in Australia, France and Ukraine. Examples of relatively food-insecure regions with increased yield variability are maize in Kenya and Tanzania and rice in Bangladesh and Myanmar. On a global scale, over 21% of the yield variability change could be explained by the change in climate variability. More specifically, the change in variability of high temperature extremes was more important than other abiotic stresses, such as low temperature extremes and soil water deficit. These findings show that while a decrease in yield variability is the main trend worldwide across crops, yields in some regions of the world have become more unstable, suggesting the need for long-term global yield monitoring so that policy makers can take measures when necessary.

The second one is the modeling study which presents the national and global yield growth patterns in coming decades under developmental pathways. In this study, I proposed country annual per capita gross domestic product-based parameterizations for the nitrogen application rate and crop tolerance to stresses. Using a global crop model combined with the parameterizations, I present global 140-year (1961–2100) yield growth simulations for the crops under shared socioeconomic pathways (SSPs) and no climate change. The model reproduces the major characteristics of reported global and country yield growth patterns over the 1961–2013 period. Under the most rapid developmental pathway SSP5, the simulated global yields for 2091–2100, relative to 2001–2010, are the highest (1.21–1.82 times as high, with variations across the crops), followed by SSP1 (1.14–1.56 times as high), SSP2 (1.12–1.49 times as high), SSP4 (1.08–1.38 times as high) and SSP3 (1.08–1.36 times as high). Future country yield growth varies substantially by income level as well as by crop and by SSP. These yield pathways offer a new baseline for addressing the questions related to adaptation costs and agricultural development under changing climate.

SEASONAL CLIMATE FORECASTS AS A PATHWAY FOR CLIMATE CHANGE ADAPTATION: A REVIEW

Mark Howden[1], Lauren Rickards[2], Steven Crimp[3]

[1] Australian National University [2] RMIT University [3] Commonwealth Scientific and Industrial Research organisation

Seasonal climate forecasts (SCF) hold out the promise for improved decision-making by reducing the 'haze of uncertainty' that clouds the future. As a risk management tool, SCF's provide a valuable but partial 'telescope' to the near future. Twenty-five years ago, the proposition was generated that seasonal climate forecasts could also be a stimulus for and eventual route to improving decision makers' acceptance of, knowledge of, and adaptation to, longer-term climate change. This proposition remains enticing but the evidence supporting it remains somewhat elusive. In this paper we critically evaluate the proposition, exploring both the potential advantages and disadvantages of the use of seasonal climate forecasts for climate change adaptation. We specifically discuss how seasonal climate forecasts can be seen as uncertain, insufficient, distracting, misleading, unnecessary and divisive as well as potentially beneficial. Hence, their effective use as an adaptation tool requires recognition of the risks they pose as well as expose. In particular, over-reliance on SCFs, poor contextualisation of the SCF knowledge products and understanding of the pathways to action, as well as limited integration with more systemic adaptation perspectives poses the risk of maladaptation. We identify several research opportunities, particularly the extent to which SCFs act as an effective boundary object within agricultural and food security adaptation efforts. Understanding the ways in which SCFs may inadvertently and implicitly undermine the steps needed to adapt to climate change in the longer term is needed in order to ensure their potential considerable benefits come to fruition. As climate change progresses, the types of adaptations needed are likely to be increasingly intensive, intentional, large-scale, complex and risky. How to use SCFs in a strategic rather than uncritical manner will be key to this progression. We use this review to contribute to the development of some general principles about what constitutes 'good' climate change adaptation practice and policy.

GLOBAL ADOPTION OF CLIMATE-SMART AGRICULTURE: EX-ANTE ECONOMIC IMPACT ASSESSMENT

Alex De Pinto, Nicola Cenacchi, Jawoo Koo, Ho-Young Kwon, Shahnila Islam
International Food Policy Research Institute

Long-term, spatio-temporally disaggregated climate change scenario data are one of the key input to IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model. The IMPACT modeling framework includes three modeling components: 1) a global partial equilibrium, multi-market food supply and demand projection model, 2) a suite of global water models (i.e., hydrology, water basin management, and water stress), and 3) the DSSAT cropping system model that estimates crop yield responses under varying management systems and environmental conditions. This presentation will present the overall architecture of the IMPACT modeling framework, describe what types of model drivers, scenarios, and climate change scenarios are incorporated, and discuss preliminary results from an ex-ante climate-smart agriculture (CSA) impact assessment study, in which co-authors investigated the biophysical and socio-economic implications of global-scale adoption of CSA technologies and practices.

SCENARIOS ON CLIMATE CHANGE IMPACTS FOR DEVELOPING APEC ECONOMIES AND HOW TO INCREASE RESILIENCE AND BENEFIT FROM OPPORTUNITIES

Dr. Maximo Torero

International Food Policy Research Institute

There is moderate consensus that temperate regions will have increased variability in temperature and rainfall, although there is no consensus on tropical regions (IPCC AR4) but clearly increased mean temperature increases risk. We combine climate models, agronomic model and economic models to simulate the impact over the economic systems of APEC Economies. We assess the effects over yields, agricultural value added, real income per capita, and on household consumption as a result of the changes in relative prices by 2050. Our results show heterogeneous effects across APEC economies. As expected we identify important increases in prices especially of sugar, cotton, vegetables, fruits, rice and other grains. The productivity losses for some farmers are in average more than compensated by the price increase but the production pattern will also be shifted significantly, the average sectoral production change is between 4 to 10%. Finally, consumption per capita of fruits and vegetables decrease across most APEC economies, with the biggest negative effects on upper and middle income economies followed by lower income economies. The exception are economies in South America and Oceania.

Despite we know the big picture in climate smart policies to cope with the risks being observed in our simulations (i.e. accelerate investments in agricultural R&D for productivity growth and climate resilience; Increase investment in rural infrastructure; regulatory reform in seed and input markets; improve extension services; and reform economic policies: open trade; land and water rights; reduction of energy, water, and fertilizer subsidies; value carbon) analysis is needed to close knowledge or information gaps regarding the degree of "climate smartness" of policies (CSA) , investments and technologies. Market signals cannot provide the necessary guidance because impacts are not easily observable and prices are missing on resilience and GHG emissions. So these need to be discovered through analysis.

In addition, climate smartness is highly location specific, so evidence needs to be spatially disaggregated. CSA forces us to shifts the emphasis from policies that aim at a single targets to policies that have multiple objectives. CSA changes the planning time horizon: policies and analyses necessarily span long time periods of 20-30 years. Therefore, CSA requires the use of integrated modeling frameworks that work at multiple geographical scales to:

- *Prioritize investments and provide an accurate understanding of tradeoffs*
- *Increase velocity of technological innovation and adoption taking into account demand side*
- *Design long-term economically and politically sustainable policies*

More importantly, given its complexity, CSA requires an even closer collaboration between policy makers and research community.

CLIMATE INFORMATION TOOLS FOR DECISION MAKING

Dr. Willingthon Pavan
University of Passo Fundo, Brazil

The challenge of agriculture today is to feed the world while being economical, environmentally, and sociable sustainable. The seasonal weather variability is well known as one of a primary source of crop production risks. The main causes of crop failures are associated with either a lack of moisture or excess of rainfall. Other production risk sources, such as insect pest/disease incidence, are also highly related to climate variability. In addition, the challenges posed by climate variability and climate change are increasingly important.

Efforts have been made to develop solutions, based on crop and insect pest/disease simulation models, to help growers to make decisions, understand the agricultural phenomena and reduce the costs with unnecessary use of pesticides while increasing the sustainability of their operations as well as minimizing the risks. Crop simulation models can be used to estimate final yield, as well as simulating growth and developmental dynamics of crops via numerical integration. Crop simulation models operate based on physiological processes that describe crop response to soil, management conditions, and the environment. Simulation outcomes can then be used to predict changes and detect trends in biophysical indicators such as crop yield, nutrient uptake, nitrate leaching, and soil carbon levels. Once set within the framework of comprehensive information and decision support system, the crop models can facilitate the efficient analysis of issues related to agricultural production. The application of crop models in risk assessment is being considered to optimize in-season management for spatially variable fields. However, these applications require accurate crop models able to simulate concurring crop stresses like insects and plant diseases. Simple growth functions-based models can be used to describe outbreaks but not to explain the underlying biological processes. Customized models could be built from this starting point to include biological processes such as the partitioning of the affected individuals into different compartments. Noteworthy is the interaction between host and pest growth. The work in our group constitutes an attempt to develop a software suite and frameworks for the simulation of both generic insect pest and disease models that can be easily coupled with crop models aiming to improve crop yield estimation under different scenarios. Our experience has shown that helping farmers to use effectively forecast and seasonal climate forecasts for reducing production risks and adapting management practices to the expected climate also enhances their ability to face potential climate impacts on crop production.

IS AGROBIODIVERSITY A KEY TO SUSTAINABLE CROP PRODUCTION IN A CHANGING ENVIRONMENT?

Dr. David Ellis

International Potato Center (CIP)

Within and between crop biodiversity is a critical component by which small holder sustenance farmers manage annual fluctuations in crop productivity. For these farmers, this often means relying on centuries old technologies for cultivation, harvesting and storage of their food crops to sustain their families until the next harvest year. The extreme changes in the Andes have greatly exacerbated the annual cycles, resulting in an unprecedented need for immediate adaptation by the farmers as well as a reassessment of the genetic material best suited for this changing landscape. In 1982 in Parque de la Papa, a valley outside of Cusco, potato landraces were cultivated by traditional means as low as 3,820 m.a.s.l. In 2016, just 30 years later, harvests of landrace potatoes in this valley are virtually nonexistent below 4,000 m.a.s.l. A shift upslope in traditional potato farming by 200 m in 30 years is extreme! But this is a reality in the Andes, and elsewhere, with a changing climate. For generations prior to climate change, Andean potato farmers have coped with the changing environment by planting 10-20+ different potato varieties, as well as an assortment of other Andean Root and Tuber crops (ARTCs) as an insurance against crop failures. If one variety does poorly this year, another will fill the gap. The genebank at the International Potato Center (CIP) is a global resource conserving the diversity vital to these farming communities and serving as an invaluable resource for maintaining, supplementing and reviving agrobiodiversity on these small holder farms. CIP holds in trust under the International Treaty for Plant Genetic Resources for Food and Agriculture the global potato collection (>4,350 landraces and >2000 wild accessions), global sweetpotato collection (>4,850 cultivated and >1,090 wild accessions) and the global collections of nine other Andean root and tuber crops. For the past 45 years, CIP has been working with the Peruvian Andean farming communities and as part of this effort, for the past 17 years, the CIP genebank has partnered with communities throughout the Peruvian Andes to give back, or repatriate, potato landraces once farmed in the areas where these communities are living. Such repatriation of germplasm back to communities is ensuring the continued availability of diversity to sustain the livelihoods of the farmers and their families in the rapidly changing environment of the Andes.

IMPLEMENTING CLIMATE INFORMATION SERVICES FOR DECISION-MAKING IN PERU

Eng. Grinia J. Avalos Roldán
National Meteorology and Hydrology Service of Peru (SENAMHI)

Based on the Statement of the Third World Climate Conference (WCC-3) in 2010, the World Meteorological Organization (WMO) decided to establish in 2011 the Global Framework for Climate Services to strengthen production, availability, supply and application of such climate services based upon scientific knowledge.

Climate Services consist of disseminating climate information to a particular user sector for the purpose of interpreting and applying information of climate evolution for decision-making. In this context, the National Meteorology and Hydrology Service of Peru (SENAMHI) has implemented interfaces with users of the agriculture sector for the provision and use of climate information, guaranteeing access, understanding and interpretation of available climate information and to promote more coherent action between scientists and users, facilitating articulated responses to social and economic interests of the country through the proper use of climate information for decision-making.

Being the northern coast of Peru a predominant agricultural region, and considering that this economic activity is closely linked to weather and climate conditions, largely modulated by the inter-annual variability of ENSO, it was necessary to implement an inter-institutional mechanism for decision-making on agriculture under the holistic view of climate services.

Session III

Long-term Solutions for Threatened Fisheries Caused by Climate Change

APEC Climate Symposium 2016

Smart Climate Information and Accountable Action:

Achieving Sustainable Food Security in a Changing World

WHERE ARE THE FISH? REDUCING CLIMATE IMPACTS ON COASTAL COMMUNITIES AND MARINE INDUSTRY

Ms. Lauren Weatherdon
UNEP World Conservation Monitoring Centre

Evidence of the influence of climate change on the productivity and ecology of marine ecosystems has been witnessed globally, with over 90% of observed warming having accumulated within the world's oceans. Projections indicate that declines in fisheries' catch are likely to occur in tropical and polar regions by 2050, with species moving towards cooler waters as the ocean warms. Impacts arising from climate change—combined with other pressures, such as overfishing and habitat degradation—are likely to affect areas of the world that depend on marine resources for economic security and access to nutrition. This talk will outline some of the proactive measures that are being applied to mitigate these impacts, such as integrated aquaculture, blue carbon, and ecosystem-based adaptation, and will highlight remaining challenges that require attention globally. This talk will also introduce some of the current initiatives by UNEP, UNEP-WCMC, and other organisations to strengthen international capacity to mitigate and adapt to the impacts of climate change on marine and coastal environments, which are important for the wellbeing of coastal communities throughout the world.

THE EFFECTS OF CLIMATE CHANGE ON THE CONTRIBUTIONS OF FISHERIES AND AQUACULTURE TO FOOD SECURITY

Dr. Johann Bell

Conservation International

By 2050, an additional 75 million Mt of fish will be needed to help feed more than nine billion people. Continued development of aquaculture and improvements to management of capture fisheries hold the promise of providing the additional fish required to maintain average, annual, global fish consumption (~20 kg per person). However, the best laid plans for increased aquaculture production and better fisheries management could be disrupted by climate change and ocean acidification. Assessments of the likely effects of increased greenhouse gas emissions on future production from fisheries and aquaculture have identified 'winners' and 'losers', both in developing country regions and globally. Negative effects are likely to be greatest in tropical and subtropical countries, with positive effects occurring mainly where waters are presently cooler. 'Win-win' adaptations are needed to enable fisheries and aquaculture to provide more fish for growing populations in a way that is resilient to climate change. In this talk, such win-win adaptations will be illustrated with examples from the Pacific Island region, which arguably has the greatest dependence on fish for food security These examples include greater investments in integrated coastal zone to protect fish habitats, diversifying methods to catch coastal fish stocks, transferring effort from coastal fisheries resources to oceanic resources, improving supply chains, and expanding small-pond freshwater aquaculture.

CURRENT AND FUTURE SITUATION OF AUSTRALIAN FISHERIES TO CLIMATE CHANGE

E Poloczanska, C Dichmont, R Pears, S Pascoe, R Deng and R Tobin
Alfred Wegener Institute

I will start by providing evidence of the impacts of climate change on marine biodiversity. Understanding how species, communities and ecosystems will be reorganised under a warmer climate are needed to inform effective conservation and management options. I will provide projections of changes in global marine biodiversity patterns, including commercial species, under climate change scenarios, using climate velocities to drive changes in species distributions. I will draw on Working Group II of the IPCC Fifth Assessment Report to discuss risks and vulnerabilities of fisheries. Commercial fisheries face risks from climate change but are also vulnerable to changes in global economic drivers and from the intrinsic structure of their businesses which may dominate decision-making in the short-term. Fisheries operate in a fluctuating and uncertain environments in terms of their practices and their business models. An existing backdrop of social, technical, economic, financial, legislative and ecological drivers influence fisheries productivity and profitability across a range of spatial and temporal scales. Against this backdrop are set the growing impacts of climate change. We ask "How well positioned are commercial fisheries for current and future challenges and opportunities?" using examples of commercial fisheries in the Great Barrier Reef, Australia through the concept of "typologies". This places businesses within Queensland in more homogenous groups compared to those based on licence holding alone. We applied a situation analysis to define and interpret the present state of fisheries typologies in terms of climate adaptation. We developed a Bayesian Belief Network that included three dimensions of vulnerability: Ecological, Macro-economics and Governance and Micro-scale (which are internal aspects that are within control of fishing businesses). We defined a set of challenges for fisheries businesses focused on the direct and indirect climate change impacts on target species however we also investigated fluctuating fuel price and a holistic management plan. The analysis provides context and a knowledge base for fishing businesses to plan.

PRODUCTIVITY AND SUSTAINABLE MANAGEMENT OF THE HUMBOLDT CURRENT LARGE MARINE ECOSYSTEM UNDER CLIMATE CHANGE

Dr. Dimitri Gutierrez Aguilar
Ocean Institute of Peru (IMARPE)

The Humboldt Current Large Marine Ecosystem (HCLME) is defined to cover 95% of the southeast Pacific, of which the Humboldt Current System (HCS) stretches from around 4 to 40 degrees south, being the most productive of the global Eastern Boundary Upwelling systems in terms of fishing yields. Ecosystem services and benefits are spread in many fields of the economy and societies. Global warming will likely affect marine circulation and land-atmosphere-ocean exchanges at the regional level, affecting the productivity and biodiversity patterns along the HCLME. Notwithstanding recent cooling trends along most of the upwelling areas, it is expected a shift towards a decrease of upwelling productivity in the next decades, which would be amplified by global trends of oxygen depletion and lower pH. In addition, higher frequency of extreme climatic events, such as El Niño in a warmer ocean, might augment the risks for the recruitment success of cold-water resources, especially in the Northern HCLME (off Peru). Non-climatic anthropogenic stressors also combines as threats for biodiversity and biomass yields, with overfishing and pollution as some of the main issues to prevent, reduce or remediate. Improvement of planning and management tools with value addition options for marine products is needed for stakeholders and local populations to adapt to climate change. The challenge for sustainable management of the HCLME goods and services under climate change also requires an effective implementation of an ecosystem-based management.

CLIMATE CHANGE EFFECTS ON THE ECONOMICS AND MANAGEMENT OF WORLD FISHERIES

Dr. Ussif Rashid Sumaila
University of British Columbia

Climate change is projected to redistribute fisheries resources while affecting the productivity of fish stocks. In turn, these changes will affect the economics and management of fisheries in many regions of the world. In this talk, I will discuss how climate change is likely to affect the revenues generated by fisheries world-wide, and using a specific case study on British Columbia, show how climate change would likely affect the household budgets of families around the world via its effects on the supply and price of fish. It seems that many families around the world would have to spend more of their food budget on seafood if they want to maintain the same level of consumption of fish in the face of climate change. I will end my talk with some suggestions on how each segment of society (individuals, cities, communities, companies, NGOs, national governments and regional and international institutes) can contribute to mitigating and adapting to the climate change effects on the economics of fisheries.

CLIMATE CHANGE, FOOD SECURITY, AND THE OCEAN: IS THERE A PATH FORWARD?

Dr. Jake Rice

Department of Fisheries and Oceans Canada

This talk will illustrate the complex web of interactions that must be considered when seeking strategies to achieve future food security in the face of climate change. The talk will first review projections of both human need for protein over the next four decades and of expected change in regional production of main crops under preferred climate change scenarios. The case will then be made for why the protein deficit must be met largely through increasing the food taken from the sea. Strategies for achieving such increases will be presented, first illustrating that simply increasing harvesting pressure while fishing in the present ways will both be unsustainable and will fail to achieve the necessary increases in yield. Alternatives may include great expansion of intensive aquaculture (both coastal and in freshwater) and different strategies for harvesting wild stocks, such as the controversial balanced harvesting of a wider range of marine organisms. Although these strategies may contribute to achieving the necessary increases in yield of fish protein for human consumption, both have serious implications for the economics of fishing and the conservation of biodiversity. These implications will be outlined. The talk will develop the argument that any pathway to food security requires rethinking strongly held policy priorities, and simple trade-off calculations are unlikely to identify globally optimal further pathways. The talk will conclude with discussing the relevance of food security, climate change, and the ocean for the "nexus approach" that DESA is developing for the 2030 Sustainable Development Goals.

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