出國報告(出國類別：其 他)

出席國際氣象研討會報告書

服務機關：交通部民用航空局飛航服務總臺

姓名職稱：王崑洲 主任

派赴國家：美國

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出席國際氣象研討會報告書

摘　要

當今世界氣象研究的議題主要都圍繞在短期劇烈天氣及氣候變遷的研究，包含颶風、暴雨、洪水、乾旱、暴風雪等劇烈的天氣變化，而長期的氣溫變化、溫室氣體的監控研究、北極夏季冰層的融化問題也是科學界關注的重點。

美國氣象學會(American Meteorological Society，AMS)及美國地球物理學會(American Geophysical Union，AGU)於美國國家大氣大學聯盟（University Corporation for Atmospheric Research ，UCAR)的所在地-博德市（Boulder City）舉辦 2008 年度會員論壇(2008 Annual Members Meeting Forum)，參與的人員除了兩會的代表外，也包含各大學相關研究領域的領導人或是研究員。此次的研討會的主要目的是針對各領域的研究成果，透過研討會方式來達成共識，並促進各項研究資源的統合應用，另外，統整有效的行動方針提供予各層行政機關的防災主管，以達有效避災的目的。

此行亦順道前往同樣位於博德市的美國國家大氣科學研究中心（National Center Atmospheric Research ;，NCAR）參加 97 年度航空氣象現代化系統強化及支援計畫（the Advanced Operational Aviation Weather System Enhancement and Support，AOAWS-ES）協調會議.，及訪問美國國家海洋暨大氣總署(National Oceanic and Atmospheric Administration，NOAA)位於博德市的地球系統實驗室(Earth System Research Laboratory，ESRL)，以了解該實驗室目前所進行的氣象模式的發展，並參觀其建置的地球三度空間資料顯示系統，以爲未來國內航空氣象發展及航空氣象服務之借鏡。回程時再順道前往長榮航空公司舊金山辦事處訪問，以了解國籍航空公司國外分公司對國內所提供的航空氣象資訊服務的滿意情況。

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目　次

壹、目的

當今世界氣象研究的議題主要都圍繞在短期劇烈天氣及氣候變遷的研究，包含颶風、暴雨、洪水、乾旱、暴風雪等劇烈的天氣變化，而長期的氣溫變化、溫室氣體的監控研究、北極夏季冰層的融化問題也是科學界觀注的重點。

美國氣象學會(American Meteorological Society，AMS)及美國地球物理學會(American Geophysical Union，AGU)於美國大氣大學聯盟的所在地-博德市舉辦 2008 年度會員論壇(2008 Annual Members Meeting Forum)，參與的人員除了兩會的代表外，也包含各大學相關研究領域的領導人或是研究員及其他國家之氣象或氣候專家。此次的研討會目的在於針對各研究領域的成果，達成共識並促進各項研究資源的統合應用，另外探討如何統整有效的行動方針提供予各層行政機關的防災主管，以達有效避災的目的。

此行職亦順道前往同樣位於博德市的美國國家大氣科學研究中心（National Center Atmospheric Research ;，NCAR）參加 97 年度航空氣象現代化系統強化及支援計畫（the Advanced Operational Aviation Weather System Enhancement and Support，AOAWS-ES）協調會議.，及訪問美國國家海洋暨大氣總署(National Oceanic and Atmospheric Administration，NOAA)位於博德市的地球系統實驗室(Earth System Research Laboratory，ESRL)，以了解該實驗室目前所進行的氣象模式的發展，並參觀其建置的地球三度空間資料顯示系統，以爲未來國內航空氣象發展及航空氣象服務之借鏡。回國時再利用舊金山轉機機會，順道前往長榮航空公司舊金山辦事處訪問，以了解國籍航空公司國外分公司對國內所提供的航空氣象資訊服務的滿意情況，進而做爲航空氣象業務改進之參考。

貳、過程

職於民國 97 年 10 月 13 日（星期一）搭乘下午 6 時 40 分長榮航空BR12 班機，於 10 月 13 日抵達落杉磯機場，20 時 04 分搭乘美國國內線邊境航空班機前往科羅拉多州丹佛市，抵達丹佛已是晚上 23 時 16 分，搭乘計程車至博德市的旅館已是午夜 1 點左右。

10 月 14 日（星期二）上午前往UCAR Center Green參加由UCAR所舉辦的氣候變遷論譠會議-，由於當天所排定之議題較偏向會員之年度會議。因此，當天上午職即轉往NCAR Foothills Lab與民航局飛航服務總臺臺北航空氣象中心（以下簡稱臺北航空氣象中心）另一位到NCAR參加航空氣象現代化系統強化及支援計畫（Advanced Operational Aviation Weather System Enhancement and Support，AOAWS-ES）97 年度協調會議的同仁張友忠先生會合，並一同出席會議，議程如附件一。會議一開始，首先由計畫專案經理Bill Mahoney先生負責簡介今年AOAWS-ES的各項工作內容；接著由Bruce Carmichael先生簡報美國FAA新一代航空氣象服務計畫；然後，再陸續由Frank McDonough先生簡報美國FAA最新積冰計畫；Jordan Powers先生簡報模式工作項目；Bob Sharman先生簡報美國FAA 最新亂流計畫與FAA目前在航空氣象相關研究計畫的最新進展及與AOAWS系統所提供的航空氣象產品之差異做詳細的比較。

10 月 15 日（星期三）職再度前往UCAR Center Green參加氣候變遷論譠會議，會議中與會代表曾針對短期劇烈天氣及氣候變遷的各項議題展開廣泛的討論，議程如附件二。會中並由PEW全球氣候變遷中心的政策分析及一般事務部副主席Vicki Arroyo女士針對美國政府的氣候政策做了詳細的報告(如附件三)，並將歷來的氣候政策、氣候目標及未來增收碳稅等政策做了分析報告。來自密西根大學自然資源與環境系的Rosina Bierbaum女士則報告了因應氣候變遷所做的廣泛及迫切的研究報告，如附件四。

10 月 16 日（星期四）職與張友忠先生由 NCARE顧問Celia Chen女士開車帶領職等前往NOAA參觀，由NOAA地球系統研究實驗室(Earth System Research Laboratory，ESRL)的全球系統部門研究員孟繁春博士爲職等解說該實驗室的各項工作(如附件五)，結束參觀後，於下午 5 時搭車前往丹佛國際機場，搭乘晚上 21 時邊境航空F9667 班機，於晚上 23 時抵達舊金山國際機場。

10 月 17 日（星期五）上午職等前往長榮航空舊金山辦事處訪問，並與舊金山辦事處蕭主任交換目前國內所提供的航空氣象服務，有那些資訊特別對該公司的國際線班機的調度影響或幫助最大。下午稍事休息後，搭乘 10 月 18 日（星期六）凌晨 1 時 30 分長榮航空BR17 班機，於臺北時間 10 月 19 日（星期日）清晨 6 時飛抵達臺灣桃園國際機場。

參、心得

一、參與氣候變遷論譠

短期劇烈天氣及氣候變遷的議題是近年來氣象界研究的主流題材，尤其是在各國近年遭遇劇烈的天災後，對於相關議題的研究及防災的整合通報等方面都做了許多的努力。瞭解區域性的氣候及劇烈天氣變化的影響並發展決策工具以使國家或該地區避過災害乃是當前急迫的事務，爲此，會中曾針對以下事項做出結論並建議予美國總統做爲施政參考：

（一） 觀測系統方面：依照美國國家研究院(National Research Council)的建議，將衛星及地面觀測系統建構成完整的地球觀測系統。

（二） 數值計算方面：大量增加用於天氣和氣候研究、預報及相關軟體用途的電腦計算資源。

（三） 研究和模擬方面：廣泛地支援基礎研究及地球科學應用或相關領域之研究，以進一步將當前天氣及氣候的研究結果與可能的影響呈現於社會大眾。

（四） 社會相關方面：支援教育、訓練、通訊的需求，以使觀測、模擬及應用工具達到最大的效能。

（五） 領導及管理方面：有效地組織領導體系以管理各項資源，維護國家之最大利益。

當前美國學界及知識界對於氣候暖化的議題已有許多的研究，也開始著手各項降低溫室氣體排放的措施，利用其強大的經濟體實力向全球宣示並以經濟管制手段來強制溫室氣體的減量，身爲地球村的一份子，必需認知溫室氣體與全球暖化問題息息相關，對於減碳對於經濟成長的衝擊亦無法自身事外，應及早做好心理準備及預防措施，以期達到全球減碳，延緩氣候暖化的目標。

二、參訪NOAA辦公室

NOAA在Boulder的地球系統研究實驗室(ESRL)是作業單位，也是研究單位，主要工作是提供全球的環境資訊(如火山爆發、野火燃燒區域等)及短期的天氣預報和長期氣候的預報。在參訪的行程中，由孟繁春博士帶領並介紹各實驗室的工作，並且參觀了所謂的SOS，也就是Science On a Sphere，他特別提到臺灣臺中的自然科學博物館在今(97)年 5 月成爲全球除了美國以外的第一個建置此項系統的單位，其系統資訊主題涵括大氣、陸地、海洋、模式和模擬及附加資料，是一個展示全球資訊的很好的平台，跳脫了以往的二維空間的展示。另外，隨著近年電腦計算能力的大幅提升，ESRL使用全新設計的全球天氣預報模式，稱爲定容 20 面體模式(finite-volume icosahedral model，FIM)，用以解決模式設計的邊界問題。目前此種模式已可產製相當好的預報產品，國內中央氣象局亦有與NOAA進行相關之合作計畫，若未來能引進國內使用，將可提供給我們AOAWS系統相當多的幫助。

三、參訪長榮航空舊金山辦事處

舊金山國際機場並無氣象觀測和資料提供單位，其機場飛行天氣資料(METAR & SPECI)是由機場管制台根據自動地面氣象觀測系統(Automated Surface Observing System，ASOS)所提供之觀測資料，經過必要之增修後，透過航空固定通信網路系統(AFTN)和終端管制廣播服務系統(ATIS)對外廣播給相關單位使用。至於機場在顯著天氣觀測方面，除了設置低空風切警告系統(Low Level Wind Shear Advisory System，LLWAS-Phase 2)用於偵測雷暴雨所引發之低空風切和微下爆氣流(microburst)外，較特別的是在舊金山國際機場和 San Carlors 機場兩個塔台頂分別架設四個影像攝影機用於觀察機場進場區之天氣變化，此套系統被稱爲機場進場區攝影系統(Airport Approach Zone Camera System)，其對機場塔台之管制作業提供相當大的幫助。

舊金山國際機場因未設置航空氣象資料供應單位，包括長榮在內之各個航空公司多自行透過網路或私人公司供應等不同管道取得資料。長榮航空公司舊金山辦事處因單位編制和設備較洛杉磯少，故所使用的氣象飛航文

件除由洛杉磯北美簽派中心製作提供外，飛行員有需要時也會自行上網至美國本土及國內民航局航空氣象服務網站(http：www.aoaws.caa.tw)查看所要資料。

四、參訪NCAR

爲配合 2025 年美國下一代國家空域系統（NAS）全面現代化計畫，長久以來，NCAR 就一直與美國 FAA 合作執行有關飛航天氣和飛航服務系統之研究計畫（Aviation Weather and Flight Service System；AWFP），其中有一項重要工作就是提升危害天氣觀測、警報和預報的準確度和信賴度，以增進美國國家空域系統的飛航管制能力，進而確保航機安全及飛行效率。此項工作已於 2008 年完成啓用，經檢視後 FAA 證明成果相當良好。

另外，爲降低天氣意外的潛在危險，及提供駕駛員在面對不利天氣或其他潛在危害天氣情況下，能做出更好和更快速的飛行決定。美國 FAA 也首度透過飛航資訊服務數據鏈路系統（Flight Information Services Data Link；FISDL），於 2003 年 12 月成功透過地面 220 個 VHF 無線電通信網路，將高度 5,000ft 至 17,500ft 及 40,000ft 以上高度的天氣圖形及數據資料上傳至航機座艙之顯示器上，供駕駛員隨時掌握航路上的即時天氣和短期預報。同時，爲簡化航空通信和降低座艙無線電網路的負荷和需求，資料亦同步傳送到所有管制席位的顯示器上。此套系統未來應會逐漸推行至美國以外地區如歐洲和亞洲之航線上，屆時，我國新的航空器有可能被要求配合架設此套設備。然而，在現今大多數航空器還未擁有此項作業能力之前，最有效的方法就是將直接危害天氣產品整合至 ATM 系統內，以便航管人員能夠及時告知在危害天氣航路上的航空器駕駛員。這種以用戶需求和航管作業爲基礎的航空氣象系統發展概念，未來將集中在航管人員、航管督導和航空管理階層的作業需要上，這亦謂著航空氣象服務的觀念，將從過去以人爲中心，所提供之天氣資訊並不太考量飛航管理需求之舊時代模式，走向以自動化爲中心，考量航空器之飛航需求並利用 ATM 系統自動整合適當天氣資料之新時代模式。

肆、建議

一、參加氣候變遷論譠

對於航空氣象而言，氣候變遷的研究對於天氣分析和天氣預報仍有著相當程度的幫助，尤其現今的航空氣象服務，已開始朝向較長時間的預報服務提供，爲此，建議應對機場的氣候做長期的監控和分析，並於可能發生天氣災害的季節加強相關的預報服務。

二、NOAA參訪

NOAA 地球系統研究實驗室研發新一代的全球天氣預報模式，目標在建立高解析度的全球天氣預報模式，以提供更高品質的預報資料。雖然目前仍在發展階段，但已有初步且令人振奮的結果，臺北航空氣象中心雖無發展天氣模式之人力與物力，但仍應密切關注此天氣模式發展的動態。另外，NOAA 在顯示科技上提供了以地球模型爲基準的三度空間顯示，將各種全球資訊，即時顯示在該球體上，此種科技不只是新奇而已，它在教育上的應用與即時解說資料的呈現都有著相當不錯的效果，倘若未來民航業有展示全球資訊的需求，當可考慮此種展示系統。

三、參訪長榮航空舊金山辦事處

經由長榮航空舊金山辦事處翟主任對於民航局航空氣象服務感到滿意的反應來看，準確的航空氣象預報確實對航空公司的營運產生相當大的效益，其中又以颱風風力及低能見度預報最爲重要。由於今年幾個侵臺颱風，臺北航空氣象中心的機場天氣預報，皆能準確的掌握到桃園國際機場的風力變化趨勢，使長榮航空由舊金山飛桃園之國際線班機皆能做出適當的調度和安排，有效解決該辦事處運務作業之困難。爲提供國籍航空公司更好的航空氣象服務，建議臺北航空氣象中心應多鼓勵預報人員多著力於颱風風力及低能見度預報之客觀研究上，以彌補人爲主觀經驗之不足。

四、參訪NCAR

一套先進的 AOAWS 系統除了能有效的提供重要航空危害天氣預報訊息給飛行員、

簽派員和航空公司作業人員去支持起飛前飛航計畫作業外、飛行中之危害天氣（如亂流、積冰、雷雨…等）的偵測資訊，如何在第一時間透過系統自動傳送至飛航管制單位做爲空中交通安全管制決策（decision-making）之用，在現今航空作業上也是一項非常重要的鍵接。爲提供安全、有序的飛航管制服務，美國 FAA 已於 2008 年在 NCAR 的協助下，完成將航空危害天氣偵測資訊整合至飛航管理系統（ATM）中，使得危害天氣和航機位置資訊，能直接傳送至管制席位的顯示器上，以幫助飛航管制人員實施安全流量管制之用。AOAWS 系統是由美國 NCAR 所研發，其系統與 ATM 的鍵接功能在建置初期即已考慮進去。因此，建議 AOAWS-ES 計畫於民國 99 年結束後，臺灣民航局應繼續與美國 UCAR 維持臺美氣象技術合作關係，以利自美國國家空域系統（Nation Airspace System，NAS）引進最新的航空天氣作業概念和關鍵技術，以提昇臺北飛航情報區之飛航安全管制能力。

伍、附錄

附件一 AOAWS-ES協調會議程

UCAR-CAA AOAWS-ES Project Fall 2008 Meeting Agenda

10/14/2008 (FL-2 Room 3099)

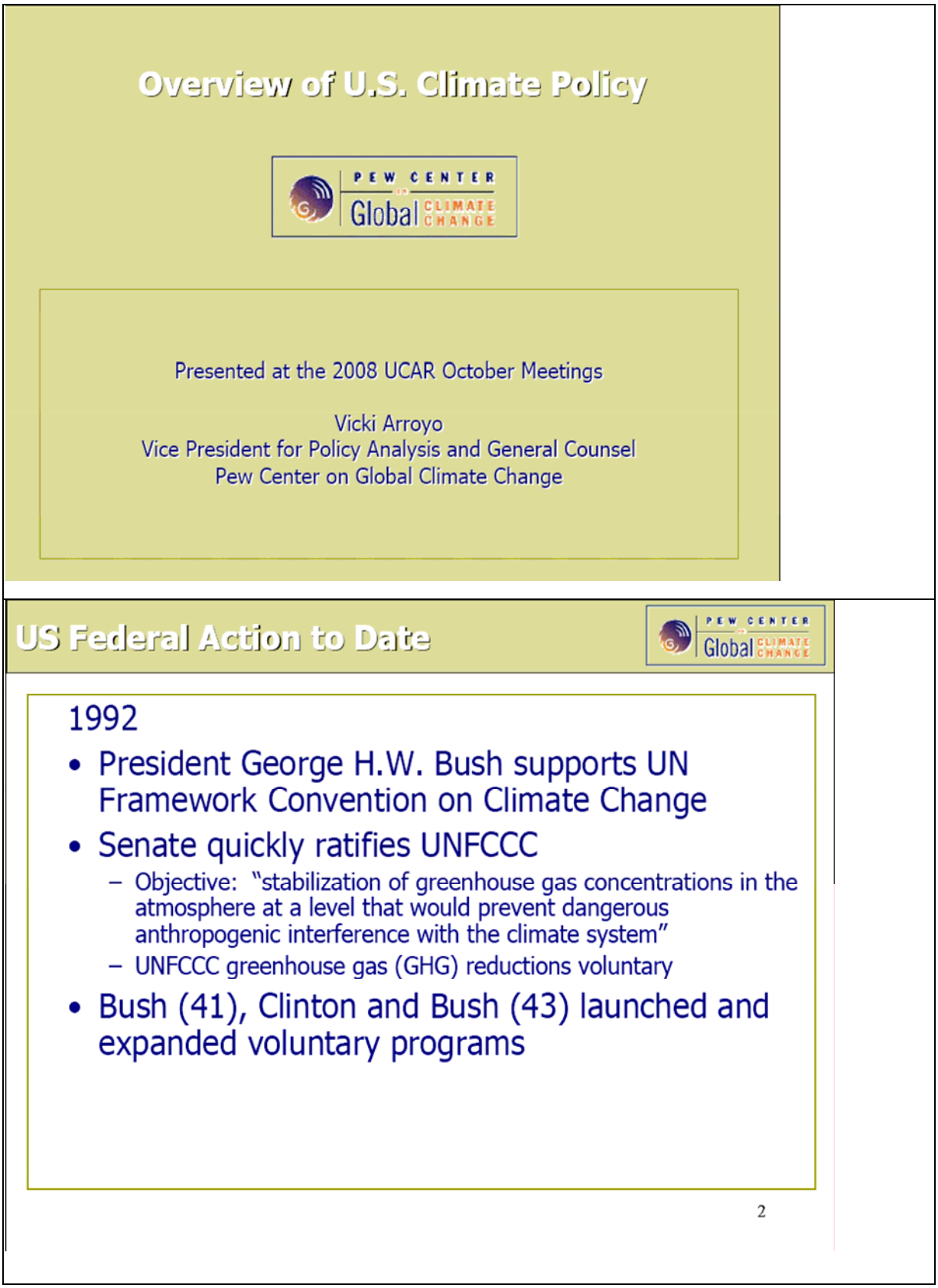
Time	Activity	Host/Speaker
11:15am	Pick-up from hotel	Celia Chen
11:30PM	Lunch	
1:00pm	Opening/welcome Short briefing on AOAWS-ES Project	Bill Mahoney
1:30pm	FAA program plans and an overview on NexGen weather	Bruce Carmichael
2:00pm	FAA icing product	Frank McDonough
2:30pm	- Modeling system development updates - Q/A and discussions	Bill Kuo, Jordan Powers, Jim Bresch
3:15pm	Coffee/Tea break	
3:45pm	FAA turbulence product	Bob Sharman

附件二 研討會議程

	General Schedule
14 October, Tuesday	Board of Trustees Meeting 8:30-11:30 am Room 3131, Center Green, Bldg. 1 (Executive Session) Academic Affiliates Meeting 7:30 am CG1, Room 3150 (Attendees are Academic Affiliate Representatives and interested others.) Annual Members' Meeting 1:00– 5:30 pm Center Green Auditorium, Bldg 1 (Open to all) Reception for the UCAR Members and Affiliate Representatives, Board of Trustees, PACUR, Early Career Faculty guests, and NCAR and UCAR management and senior staff 5:30pm Center Green, Building 1
15 October, Wednesday	Annual Members' Meeting 8:30 am-3:00pm Center Green Auditorium, Bldg. 1 President's Advisory Committee on University Relations (PACUR) Meeting 3:30-7:00 pm

	Room 3131, Center Green, Building 1 (Attendees are the President’s Advisory Committee on University Relations and interested others.)

附件三 美國氣候政策總覽



US Federal Action to Date

1993 - 2000

- Senate passes Byrd-Hagel resolution opposing U.S. participation in a climate treaty that does not require GHG reduction commitments from developing countries, 95 – 0 (1997)
- Clinton supports 1997 Kyoto Protocol, but offers no legislation to meet Kyoto's requirements
- In Congress, a "No Man's Land" between Kyoto and do-nothing

3

US Federal Action to Date

2001 – 2006

- G.W. Bush opposes Kyoto, breaks promise to limit power plant CO_2 emissions (2001)
- Democrats and moderate Republicans begin to offer climate proposals (2001)
- Large minority of Senators vote for McCain-Lieberman GHG cap-and-trade bill (2003)
- Majority of Senators vote for nonbinding resolution supporting mandatory climate action (2005)

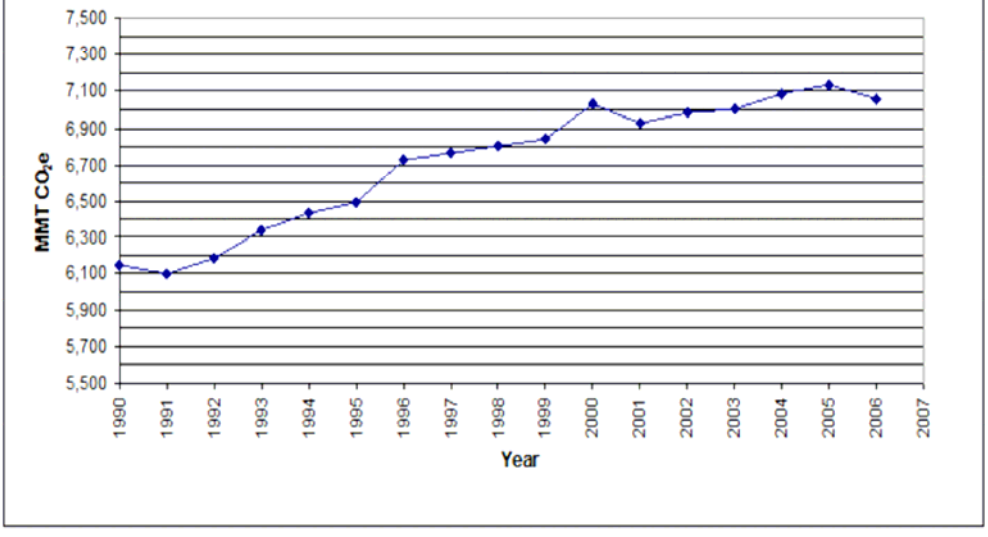
4

Bush Federal Climate Policy

- No Kyoto
- Research
- GHG Intensity target
- Voluntary reporting
- Long-term technology development

5

U.S. GHG Emissions 1990-2006



Source: US EPA

6

What is Cap and Trade?

PEW CENTER Global CLIMATE CHANGE

Cap and trade basics:

- Determine what facilities and GHG gases are covered by the policy
- Set the level of allowable GHG emissions – the "cap"
- Distribute tradable allowances (permits to emit) to the covered facilities
- Covered facilities must hold enough allowances at the end of the compliance period to cover their emissions
- Those facilities with excess allowances can sell - or "trade" - allowances to facilities that do not have enough to cover their emissions
- Trading occurs because firms face different costs of reducing emissions
- The "cap" declines over time creating scarcity and a robust market for allowances

Cap and trade puts a price on GHG emissions and creates an incentive to reduce emissions

7

Why Cap and Trade?

PEW CENTER Global CLIMATE CHANGE

Advantages of cap and trade:

- GHGs are well-mixed in the atmosphere, therefore…
  - The location of reductions is irrelevant
  - Might as well get the cheapest reductions first
- Making the policy fit the environmental goal
- International linkage
- Providing positive incentives to innovation
- Growing support and experience

But keep in mind…

- Some sectors are difficult to address through cap and trade. Other policy mechanisms (R&D, sectoral programs) will likely be needed as well

8

Congressional Debate 2007 - 2008

- So far in 110th Congress (2007-2008) there have been 213 hearings held and 235 bills introduced
- 2007 Energy Bill has effect on GHG emissions:
  - Vehicle efficiency standards
  - Renewable fuel standard
  - Appliance efficiency standards
- Today in Washington, "climate bill" generally = GHG cap-and-trade bill

9

Congressional Debate 2007 - 2008

Tough questions to answer:

- ***What targets and timetable?***
- Which industries are covered by program?
- How to allocate or auction GHG allowances? How to contain program costs?
- ***How to ensure offset quality?***
- How to promote rapid deployment of low-carbon technologies? (including carbon capture & sequestration of coal power emissions)
- How to protect US manufacturers from price advantage for imports from countries without GHG mitigation programs?

10

Cap and Trade Bills in the 110th

Senate

- Lieberman-Warner: economy-wide, funds for technology, adaptation, and mitigating impacts. Approximately 66% below total U.S. 2005 emissions levels by 2050
- Bingaman-Specter: offsets, "safety valve" of $12/ton rising 5%/year above inflation, funds and bonus allowances for tech R&D. Aspires to ≥ 60% below current by 2050. Requires aggressive external policies to avoid safety valve
- Lieberman-McCain: economy-wide, technology title. 60% below 1990 in 2050
- Sanders-Boxer: economy-wide, cap & trade permitted but not required, other sectoral standards. 80% below 1990 in 2050
- Feinstein-Carper: electricity sector only, funds for tech R&D. 25% below 1990 in 2050
- Kerry-Snowe: economy-wide, other sectoral standards, funds for tech R&D. 62% below 1990 in 2050

House

- Markey: economy-wide (7 GHGs), almost 100% auction with proceeds to tax rebates for energy consumers, 85% below 2005 levels in 2050
- Olver-Gilchrest: economy-wide, 60% below 1990 in 2050
- Waxman: economy-wide, cap & trade permitted but not required, funds for tech R&D, other sectoral standards. 80% below 1990 in 2050

11

Lieberman-Warner Highlights

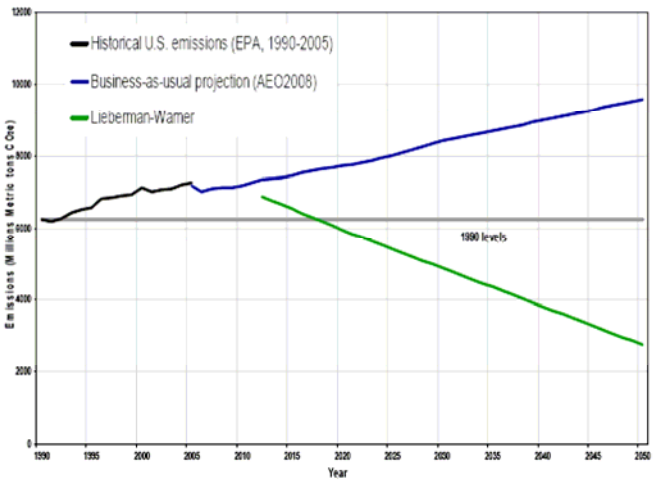
- Covered sectors represent approximately 87% of total U.S. emissions
  - Downstream on coal (power plants and industries using over 5,000 tons of coal per year)
  - Upstream (producers and importers) on natural gas, petroleum, or coal-based liquid or gas fuels (assuming no sequestration or destruction)
  - Manufacturers or importers of >10K t/CO_2e of GHGs (e.g., SF_6, PFCs) assuming no sequestration/destruction
  - Facilities that emit HFCs (>10K tons) as byproduct of HCFC production (note: separate cap for HFC consumption)

  But…
  - Many industrial process emissions are not covered (e.g., cement, lime, and aluminum production) totaling roughly 104 MtCO_2e (1.4% US emissions)
  - Emissions from agriculture, landfills, etc. not covered – 826 MtCO_2e (11% US emissions)

12

Lieberman-Warner Targets

- Emissions caps require reductions across covered sectors below 2005 levels as follows:
  - 2012: 4%
  - 2020: 19%
  - 2050: 71%
- Reductions in total U.S. emissions would depend on the growth in uncovered sectors, use of offsets, etc.



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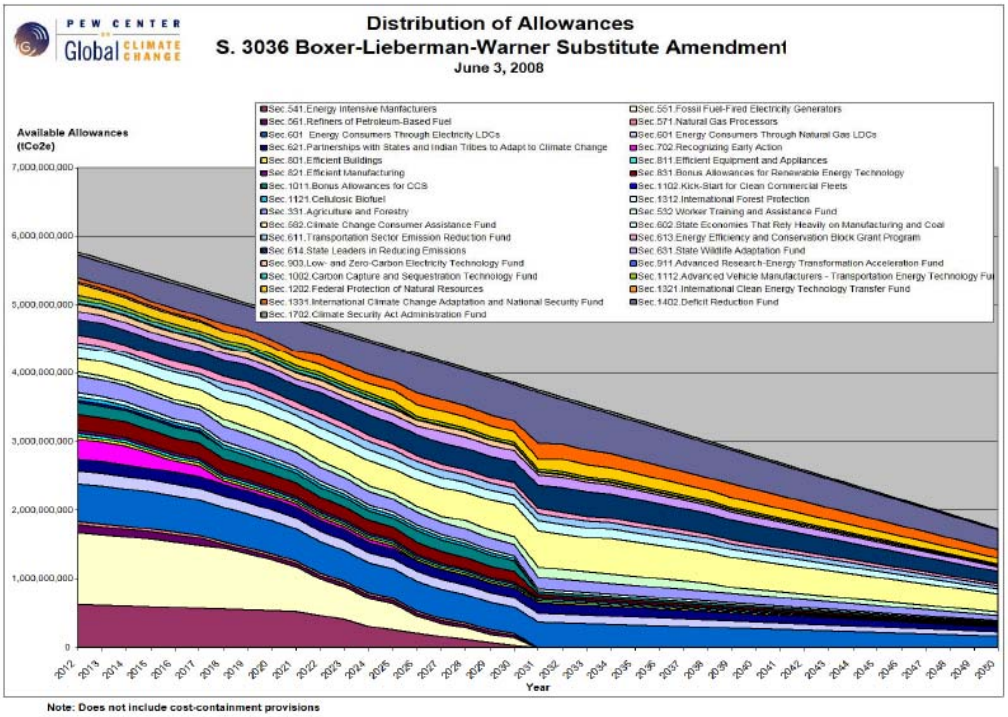
Lieberman-Warner Allocation



Note: Does not include cost-containment provisions

Lieberman-Warner Debate

Senate held a "debate" on Boxer-Lieberman-Warner GHG cap-and-trade bill, June 2 – 6, 2008 :

- Debate was very disappointing
- No votes were held on amendments
- No final vote was held on the bill itself
- The vote on whether to amend and have a final vote on bill failed
- Too much discussion of gasoline prices and the economy
- Too little understanding of the negligible effect of B-L-W bill would have on gasoline prices and economy

15

Lieberman-Warner Highlights

Cloture votes on Boxer-Lieberman-Warner (S.3036)

Yes: 48

Akaka (D-HI)	Inouye (D-HI)	**Pryor** (D-AR)
Baucus (D-MT)	Kerry (D-MA)	Reed (D-RI)
Bayh (D-IN)	Klobuchar (D-MN)	Reid (D-NV)
Bingaman (D-NM)	Kohl (D-WI)	Rockefeller (D-WV)
Boxer (D-CA)	Lautenberg (D-NJ)	Salazar (D-CO)
Cantwell (D-WA)	Leahy (D-VT)	Sanders (I-VT)
Cardin (D-MD)	**Levin** (D-MI)	Schumer (D-NY)
Carper (D-DE)	Lieberman (ID-CT)	**Smith** (R-OR)
Casey (D-PA)	**Lincoln** (D-AR)	Snowe (R-ME)
Collins (R-ME)	**Martinez** (R-FL)	Stabenow (D-MI)
Dodd (D-CT)	McCaskill (D-MO)	**Sununu** (R-NH)
Dole (R-NC)	Menendez (D-NJ)	Tester (D-MT)
Durbin (D-IL)	Mikulski (D-MD)	**Warner** (R-VA)
Feingold (D-WI)	Murray (D-WA)	Webb (D-VA)
Feinstein (D-CA)	Nelson (D-FL)	Whitehouse (D-RI)
Harkin (D-IA)	**Nelson** (D-NE)	Wyden (D-OR)

Ten signed letter indicating would not have voted for the Boxer substitute in its current form but expressing support for climate policy: Stabenow, Rockefeller, Levin, Lincoln, Pryor, Webb, Bayh, McCaskill, Brown, and Nelson

No: 36

Alexander (R-TN)	Corker (R-TN)	Johnson (D-SD)
Allard (R-CO)	Crapo (R-ID)	Kyl (R-AZ)
Barrasso (R-WY)	Domenici (R-NM)	Landrieu (D-LA)
Bennett (R-UT)	Dorgan (D-ND)	Lugar (R-IN)
Bond (R-MO)	Ensign (R-NV)	McConnell (R-KY)
Brown (D-OH)	Enzi (R-WY)	Roberts (R-KS)
Brownback (R-KS)	Grassley (R-IA)	Sessions (R-AL)
Bunning (R-KY)	Hagel (R-NE)	Shelby (R-AL)
Burr (R-NC)	Hatch (R-UT)	Thune (R-SD)
Chambliss (R-GA)	Hutchison (R-TX)	Vitter (R-LA)
Coburn (R-OK)	Inhofe (R-OK)	Voinovich (R-OH)
Cochran (R-MS)	Isakson (R-GA)	Wicker (R-MS)

Not Voting: 16

Biden (D-DE)	Craig (R-ID)	Murkowski (R-AK)
Byrd (D-WV)	DeMint (R-SC)	Obama (D-IL)
Clinton (D-NY)	Graham (R-SC)	Specter (R-PA)
Coleman (R-MN)	Gregg (R-NH)	Stevens (R-AK)
Conrad (D-ND)	Kennedy (D-MA)	
Cornyn (R-TX)	McCain (R-AZ)	

Six sent letters indicating would have voted yes if had been present: Biden, Clinton, **Coleman**, Kennedy, McCain, and Obama

16

Lieberman-Warner Highlights

Still, something can be learned from event

- Underlying B-L-W bill did not have enough support – perhaps no more than 35 – 40 Senators
- Nevertheless, a majority of U.S. Senators support mandatory climate action, probably in the form of GHG cap-and-trade
- However, the design of the cap-and-trade program is still very controversial
- Without strong presidential leadership, the debate could last for years

17

Look-back provisions in S.3036

Boxer-Lieberman-Warner substitute calls for a detailed analysis every 3 years from the National Academy of Sciences of:

- The latest scientific information and data relevant to GCC, which should:
  - Address existing reports including most recent IPCC assessment
  - Describe trends in and projections for total US GHG emissions, total worldwide GHG emissions, atmospheric concentrations of GHGs, global average temperature, adverse impacts of GCC on humans, wildlife, and natural resources, and health of the oceans
- The performance of the Act in reducing GHG emissions and mitigating the adverse impacts of GCC, including:
  - The extent to which the Act and other policies…
    - will prevent dangerous atmospheric concentrations of GHGs and increases in global average temperature
    - are accelerating development and commercial deployment of low-emissions technologies
  - Projected deployment of capture, efficiency, zero-emissions energy, and biological sequestration technologies
  - The extent to which the allocations and distributions of allowances and auction proceeds are advancing the purposes of the Act, and whether they should be modified
  - Whether the Act or responses to the Act have increased release of criteria, hazardous, and toxic pollutants
  - The feasibility of reducing the cap or establishing additional policies

18

Look-back in S.1766

- In the Bingaman-Specter bill, the NAS is called to "develop periodic and timely reports on the status of the best available science and the status of technologies to reduce, sequester, or avoid GHG emissions"
- Additional look-back provisions focus more on whether comparable action has been taken by foreign countries and whether the safety-valve provisions are working; appropriately, these questions are not directed at the science community

19

House state of play

House Energy and Commerce Committee

- Motivated leadership
  - Chairman John Dingell (D-MI)
  - Subcommittee on Energy and Air Quality Chairman Rick Boucher (D-VA)
- Reps Waxman (D-CA) and Markey (D-MA)
- Some moderate Republicans
- Very smart productive committee
- Discussion draft released October 7th

20

Dingell-Boucher Discussion Draft

Proposal highlights:

- Economy-wide: covers 88% of U.S. GHG emissions
- Covered sources: power plants, fuels, large industrial facilities, bulk gas producers, natural gas LDCs, and geologic sequestration sites
- Covered emission targets: 6% below 2005 by 2020, 44% below 2005 by 2030, 80% below 2005 by 2050
- Cost-containment: banking, borrowing, and strategic allowance reserve
- EPA-approved international and domestic offsets (5% of compliance obligation in first 5 years, 35% by 2024)
- Four allowance allocation options

21

Dingell-Boucher Discussion Draft (cont)

Highlights (cont.):

- FERC responsible for carbon market oversight
- Energy efficiency standards and incentives for clean technologies
- Performance standards for new coal-fired power plants

But…

- Concerns with near-term reduction targets and preemption of Clean Air Act and state regulations

22

Look-back in Dingell-Boucher Discussion Draft (cont.)

- Look back studies for overall policy effectiveness for mitigation and risk reduction

Dingell-Boucher calls on a detailed analysis ever 8 years from the NAS of:

- a review of the latest scientific information that
  - address existing reports (e.g., IPCC, CCSP)
  - describes trends and projections for emissions, CC indicators (e.g., temp, precip, SLR), and impacts on humans and ecosystems
  - assesses the potential occurrence of key milestones (e.g., 450 ppm CO2e, 2 C warming, slowing of the THC)
- an analysis of the performance of the Act and other public policies in mitigating GHG emissions
- an analysis of the performance of the Act in reducing the risks from CC impacts

23

Look-back in Dingell-Boucher Discussion Draft (cont.)

- Assessing state and local efficiency programs

Not later than three years after enactment NAS will conduct a study of and develop recommendations for:

- improving the accuracy of data on vehicle miles traveled and transportation system efficiency for the purposes of tracking greenhouse gas emissions and
- assessing the effectiveness of policies to reduce vehicle miles traveled and increase transportation system efficiency

24

Look-back in Dingell-Boucher Discussion Draft (cont.)

- Science advisory board for adaptation

The Act establishes the NATURAL RESOURCES CLIMATE CHANGE ADAPTATION SCIENCE AND INFORMATION PROGRAM under the National Global Warming and Wildlife Science Center within the United States Geological Survey to:

- provide assistance to stakeholders in assessing impacts of CC
- conduct and sponsor research to aid in adaptation
- assist federal agencies in developing mandatory adaptation plans

The program is overseen by the SCIENCE ADVISORY BOARD to advise the program on the latest science and to recommend scientific priorities:

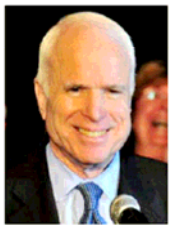
- 10-20 members, at least half recommended by the President of the NAS
- expertise related to impacts, vulnerability, adaptation
- balanced membership from federal, state, local gov't, academe, and NGOs

"The advice and recommendations of the Science Advisory Board shall be made available to the public."

25

Presidential Candidates

Candidates Support Cap and Trade



McCain is a long-time advocate for climate action. McCain-Lieberman cap and trade bill proposed in 2003

Obama supports 80% emission reductions by 2050.

26

The Next President and Congress

The next President:

- Is expected to propose a framework for GHG cap-and-trade bill in first half of 2009;
- Can focus public attention on climate change;
- Can put pressure on Congress; and
- Is expected to be the single biggest force in Congressional debate.

27

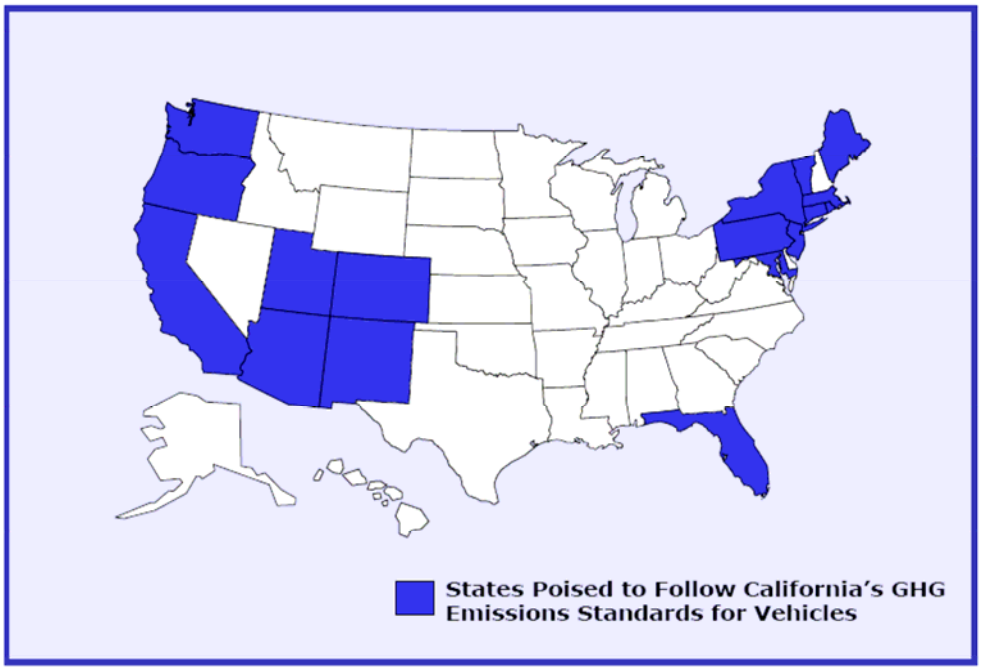
The Next President and Congress

However:

- Gasoline prices and economic recession are still likely to be issues;
- Coal, oil and gas states have the same interests, whether represented by Democrats or Republicans; and
- It will take the President months to put his team in place.

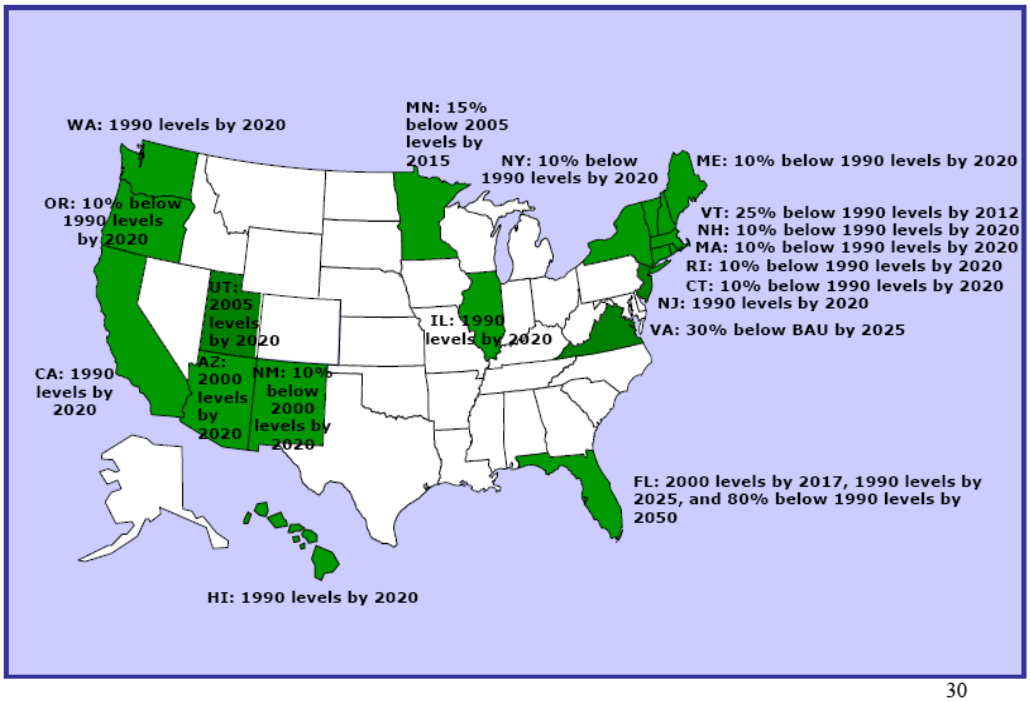
28

State Vehicle GHG Standards



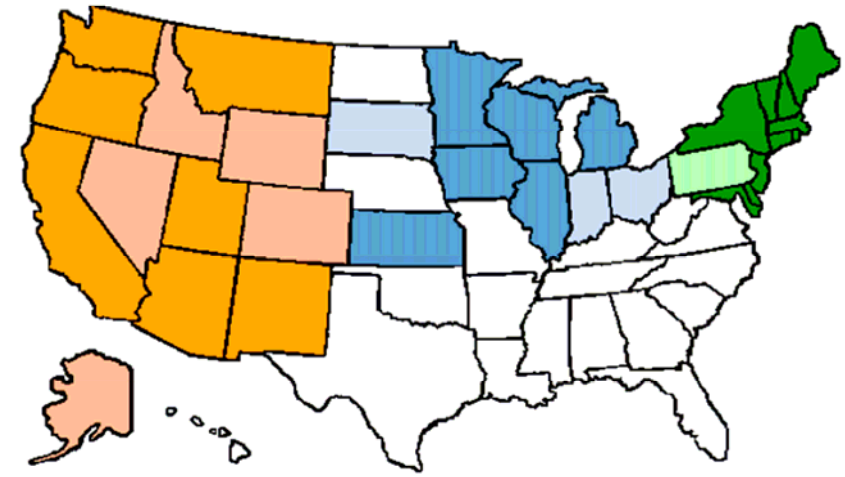
29

19 States with GHG Emission Targets



30

Regional Cap-and-Trade Initiatives



- Regional Greenhouse Gas Initiative RGGI
- RGGI Observer
- Midwestern Regional GHG Reduction Accord
- MRGHGRA Observer
- Western Climate Initiative
- Western Climate Initiative Observer

31

The Role of State and Federal Governments

- Question is not whether responsibility for climate change action should rest exclusively with the federal government *or* the states, but rather how they should *share* responsibility.
  - Given the relative historical competencies of state and federal governments, there will be a substantial role for each in future climate policy; history of environmental policy shows that a shared approach is more effective
  - Some aspects of policy (e.g., cap-and-trade if stringent enough) can be more effectively implemented at federal level
  - Others (transportation, land-use planning, renewable energy) can be more effectively achieved by states

32

Business Developments

- Growing belief in US industry that climate action is now inevitable and possibly desirable
- Increasing number of businesses:
  - Want regulatory certainty
  - Concerned that Supreme Court will require US Environmental Protection Agency to regulate GHGs
  - Concerned about court vacating CAIR rule (4 P more attractive now?)
  - Concerned with state action
  - Concerned with US public pressure
  - Already experience GHG regulation in European Union
  - Want US to influence post-2012 treaty negotiations

33

USCAP Partnership

34

International Negotiations

- At COP 15, the US is likely to:
  - signal willingness to accept a declining cap on US emissions, and
  - insist on binding commitments of some sort for developing countries.
- Under either Obama or McCain, U.S. is likely to be more constructive in negotiating a climate treaty than under Bush.

35

What's Needed?

- Overall needs from the scientific community
  - Scientific tools (e.g., regional climate models)
  - Improved information delivery to stakeholders
    - Accessible to the public
    - Easily understood and navigated (e.g., using internet resources)
  - Framework for policymakers to understand information provided and make decisions
  - What constitutes "dangerous interference with the climate system" (DAI)?
    - Scientists and policymakers have declined to answer--discussion of mitigation targets led by economists with a focus on DIE (dangerous interference with the economy)
    - Need well-vetted science-based arguments to inform the DAI question to get balanced approach to setting targets

36

What's Needed? (cont.)

- From UCAR
  - Increased integration of social sciences into University decision-maker partnerships to develop integrated analytical and decision-making tools
  - Continued focus on scientific/environmental information for federal and international mitigation debate
  - Understanding geoengineering options and risks
  - Assistance with adaptation (regional scale modeling, etc.)
  - Be proactive—what is missing?

37

A two-tiered approach needed

"Avoiding the unmanageable and managing the unavoidable"*

- Avoiding the unmanageable → mitigation
  - Emissions reduction policies at state, regional, federal, and international levels
- Managing the unavoidable → adaptation
  - Preparedness, resilience, ecosystem management, protecting vulnerable populations

*Title of the UN Foundation Scientific Expert Group Report on Climate Change and Sustainable Development

38

Adaptation

PEW CENTER on Global CLIMATE CHANGE

Chicago Tribune

The first refugees of global warming

Bangladesh watches in horror as much of the nation gives way to sea

By Laurie Goering
Tribune foreign correspondent
Published May 2, 2007

ANTARPARA, Bangladesh -- Muhammad Ali, a wiry 65-year-old, has never driven a car, run an air conditioner or done much of anything that produces greenhouse gases. But on a warming planet, he is on the verge of becoming a climate refugee.

In the past 10 years the farmer has had to tear down and move his tin-and-bamboo house five times to escape the encroaching waters of the huge Jamuna River, swollen by severe monsoons that scientists believe are caused by global warming and greater glacier melt in the Himalayas.

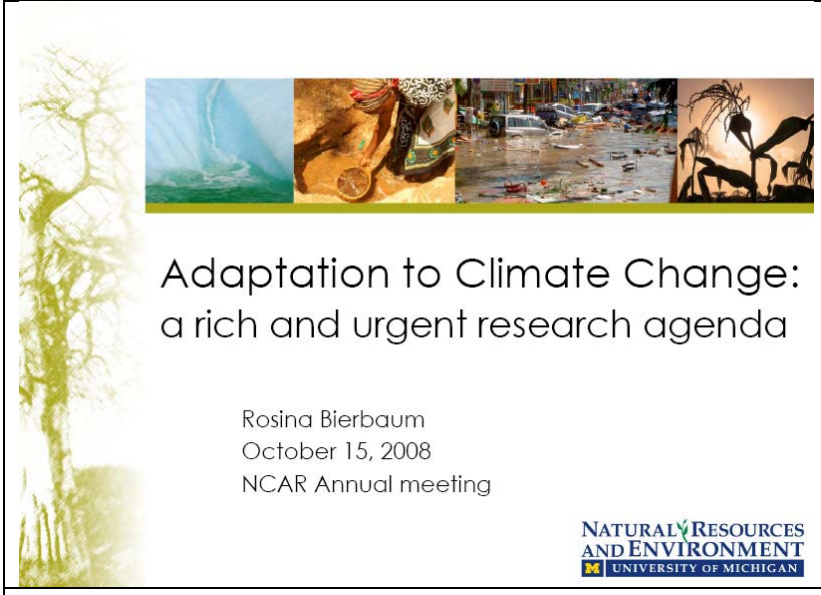
Now the last of his land is gone, and Ali squats on a precarious piece of government-owned riverbank -- the only ground available -- knowing the river probably will take that as well once the monsoons start this month.

"Where we are standing, in five days it will be gone," he predicts. "Our future thinking is that if this problem is not taken care of, we will be swept away."...

Source: ESRI Chicago Tribune

39

附件四 因應氣候變遷的廣泛及迫切的研究



Adaptation to Climate Change:
a rich and urgent research agenda

Rosina Bierbaum
October 15, 2008
NCAR Annual meeting

NATURAL RESOURCES AND ENVIRONMENT
UNIVERSITY OF MICHIGAN

Climate Change: What do we know?

- Past is not prologue…and the pace of change is quickening
  - Infrastructure and natural resource management and planning based on the last 100 years of climate will be wrong
  - Design features of infrastructure and tolerances of species will be exceeded
- Committed to further climate changes
  - Adaptation is occurring, even if unplanned
- Degree of warming matters
  - Mitigation makes a difference
- Its not just the averages that matter…
  - Regional and local variances; seasonal changes; Extreme events
- Need a Portfolio Approach:
  - Adaptation and Mitigation—but there are interlinkages across the two!
- Adaptive Management is needed
  - In all sectors and regions
- Investment is not commensurate with the urgency of the problem…
  - Need integrative regional assessments involving stakeholders

- Need prioritization of policy-relevant research needs across fields, not laundry lists
- Need transformational not evolutionary change

Climate Change: What do we know?

We are REALLY not addressing these !!!

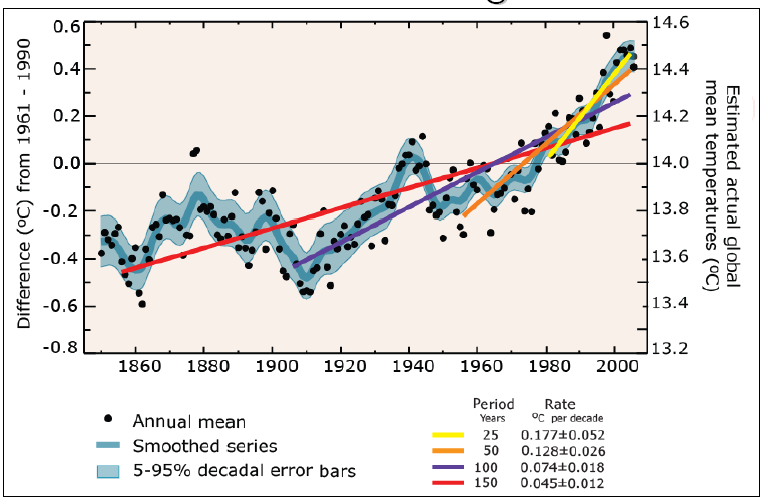
…is not prologue…and the pace of change is quickening

- …astructure and natural resource management and planning based on the …00 years of climate will be wrong
- …features of infrastructure and tolerances of species will be exceeded

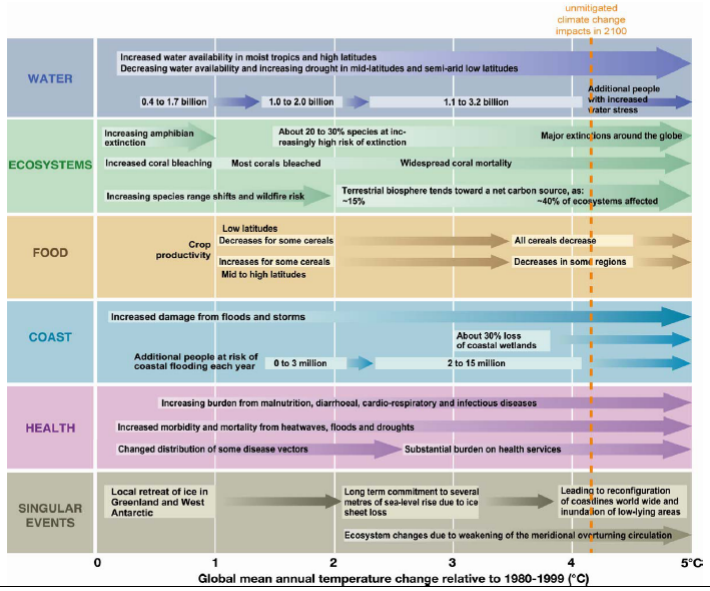
- **Con… further climate changes**
  - Ad… is occurring, even if unplanned
- **Degree o… matters**
  - Mitigati… difference
- **Its not just the …that matter…**
  - Regional ar… variances; seasonal changes; Extreme events

- **Need a Portfolio Approach:**
  - Adaptation and Mitigation—but there are interlinkages across the two!
- **Adaptive Management is needed**
  - In all sectors and regions…simultaneously
- **Investment is not commensurate with the urgency of the problem…**
  - Need integrative regional assessments involving stakeholders
  - Need prioritization of policy-relevant research needs across fields, not laundry lists

Global average temperature is rising at an accelerating rate



GLOBAL KEY IMPACTS (from IPCC WGII Technical Summary, 2008)



Negotiating conundrums

- How can sustainable development be enhanced while tackling climate change?
- How can we deal with increasing competition for land, water, and water
- How can we stop at a 450-550 ppm world?
- A global deal? Or not? By when?
- Where can innovation get us in the next 20-30 yrs? What is needed? What are people willing to do?
- Will we have or can we create ‘teachable moments’ & ‘transformative times”?

GCRP 2000—Draft Goals for the Second Decade:

Developing and Applying Forecasts of Change at Scales Relevant to Decisionmaking

1. Extend our Knowledge of the Earth System
2. Evaluate Vulnerability and Resilience
3. Assess global change in the context of other environmental and social changes
4. Science for Society: Information for Decisionmaking
5. Understand Global Change in Particular Locations: The Need for Integration

OSTP, 2000, draft report

CCSP Goals 2003

- Goal 1: Improve knowledge of past and present climate and environment, including natural variability
- Goal 2: Improve quantification of the forces bringing about changes in climate & related systems
- Goal 3: Reduce uncertainty in projections of how the Earth's climate and related systems may change in the future
- Goal 4: Understand the sensitivity and adaptability to climate and related global changes
- Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities.

The Revised Research Plan

(one of the court-ordered documents released in May 2008)

re-affirmed the current five goals…

Adaptation options include: *planning/management, technology, institutions, monitoring, & R&D*

- Infrastructure to withstand new "extremes"
- Linking of reservoirs to enhance supply
- Seed banks, mass propagation techniques
- Emergency response plans
- Early warning alert systems / surveillance
- Incentives / Disincentives / insurance
- Prioritize lands to preserve
- Design of migration corridors

Climate Change: Adaptation Needs

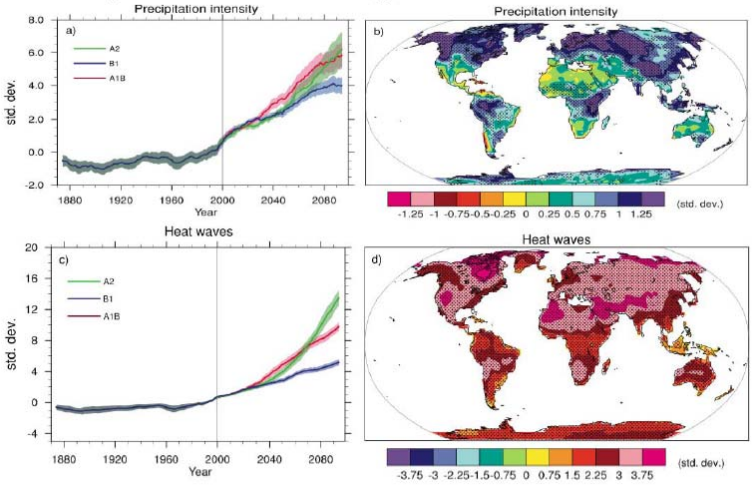
Four essential categories of analysis needed

to develop adaptation options

- Evaluate the impacts of Multiple Stresses on systems

- Conduct regional assessments
- Prepare for Extreme Events and their Consequences
- Explore the intersection of mitigation and adaptation

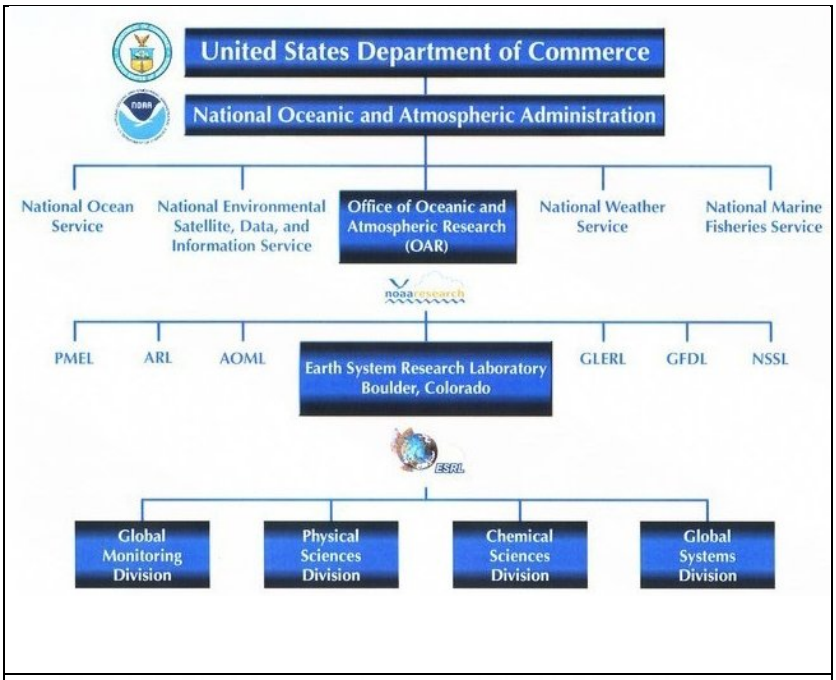
Projected changes in extremes



The Opportunity for UCAR and its Members

- Initiate regional vulnerability assessments/scenarios analyses
- Evaluate multiple environmental stresses & climate change in concert and develop solutions that are robust
- Identify strategies to manage changes and build resilience in/across all sectors
- Help develop best practice toolkits for water management, land use change, city planning, etc.
- Train the next generation workforce in new ways!
- Improve the flow of information to support collective action and decisionmaking -- from the rotary club, to the Congress and the White House

附件五 美國海洋暨大氣總署地球系統研究實驗室簡介資料



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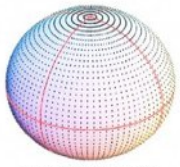
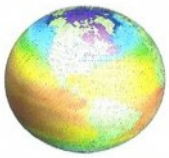


The lat/lon is a traditional model grid used to make numerical forecasts.



An icosahedral grid, such as the FIM, is the most uniformly distributed geodesic grid suitable for weather and climate models.

Global Systems Division
Dr. Steven Koch, Director
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325 Broadway
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Earth System Research Laboratory

Putting Tools in the Hands of Users

ESRL Develops New Climate and Weather Prediction Model- the FIM

A new computational design for a global icosahedral model is currently under development at the Global Systems Division (GSD) of NOAA's Earth System Research Laboratory (ESRL). GSD is collaborating with the Environmental Modeling Center at the National Centers for Environmental Prediction (NCEP) to research and test this "Flow-following"-finite volume Icosahedral Model, known as the FIM.

What is an icosahedron?

FIM is based on the principle of a solid 20-sided geometric figure known as an icosahedron. The FIM coordinate system consists of a large number of hexagonal cells (with 12 embedded pentagons).

Flow-following coordinates reduce nonphysical errors

FIM's name originates from the fact that it is a finite-volume icosahedral model that solves shallow-water flow in combination with a flow-following vertical coordinate whose surfaces move freely according to airflow. These coordinate surfaces aloft are defined by a constant potential temperature, making it flow following. This coordinate system allows for a reduction of nonphysical errors in the model.

Unique grid cell shapes allow conservative finite-volume numerics

This new grid-point model, in a sense, "molds" over the globe providing quasi-uniform coverage with minimal regional variation. The variations can be kept minimal due to the shape of the grid cells. The FIM is particularly suitable for finite-volume numerics whose conservative operators can be easily approximated as line integrals along cell boundaries.

Potentially produces more accurate numerical weather predictions

FIM runs real-time weather forecasts twice daily as part of a verification process proposed by NCEP. These runs and other research have proven that the desirable "conservativeness" of the model can potentially result in better overall numerical predictions.

FIM meets NOAA's Mission Goal

ESRL's efforts to improve local and global weather prediction models enhance our customers' preparedness for responding to hazardous weather- and water-related conditions. These efforts are also applied to improving medium-range weather prediction and responding to climate prediction needs.

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GSD's state-of-the-art high-performance supercomputer, wJet, and award-winning facility at NOAA's Earth System Research Laboratory in Boulder, CO.

ESRL

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Earth System Research Laboratory

Putting Tools in the Hands of Users

ESRL's High-Performance Supercomputers and Facility

Where would our science be without the support of supercomputing power to process the sophisticated equations and data volume needed in research? NOAA's Earth System Research Laboratory (ESRL) supports some of the nation's top scientists' research demands with continuous high-performance computing capabilities in a recently constructed, state-of-the-art data center.

What is a supercomputer?

It is a system built to accommodate the storage and speed necessary to process complicated numerical calculations. This allows extraordinarily complex forecasts to be performed by breaking the math into hundreds of thousands of smaller, more manageable, and reliable calculations.

Computer ensemble capabilities

As technology advances, so does the need to raise the volume of complex data and equations that can be processed by our scientists. That is why NOAA's new R&D high-performance computer, wJet, was added to ESRL's existing supercomputing resources, eJet and iJet. A comparison of computing capabilities between iJet and the new wJet illuminates the rapid development in this changing environment. iJet is composed of over 1300 32-bit Intel central processing units (CPUs). Each CPU is capable of 4.4 billion arithmetic operations per second. wJet raises that volume drastically to meet both current demands and those of the future. It consists of 1424 64-bit Intel CPUs. Each CPU is capable of performing over 10 billion arithmetic operations per second for a total capability of 15.2 trillion arithmetic operations per second, ranking this computer in the top 150 in the world.

Award-winning facility

ESRL's new 2,060-square foot computing facility, housed at the NOAA campus in Boulder, Colorado, is managed by the laboratory's Global Systems Division (GSD). The room's award-winning design can handle the rigorous environmental and electrical demands of wJet. State-of-the-art ambient air cooling and a clean-agent fire protection system, as well as numerous sophisticated facility environment monitoring and control safeguards are features that add up to a highly reliable and resilient center. It enhances NOAA's ability to facilitate the efficient and timely delivery of products and services.

Support and applications

These robust supercomputers support a wide variety of applications. Serving a number of NOAA and other research labs, plus university collaborators, ESRL's computing system aids scientists in making short-term weather and climate forecasts. The calculating power and volume-handling storage allow scientists to produce more accurate ocean, air quality, and environmental models that lead to a better understanding of our complicated Earth system.

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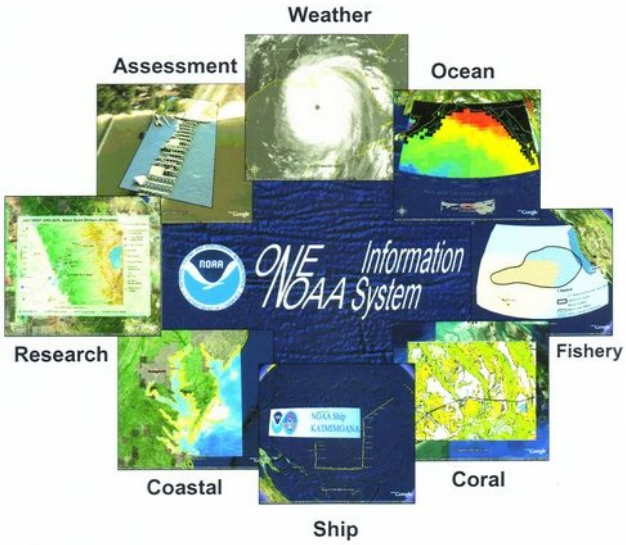
ONE NOAA Information System

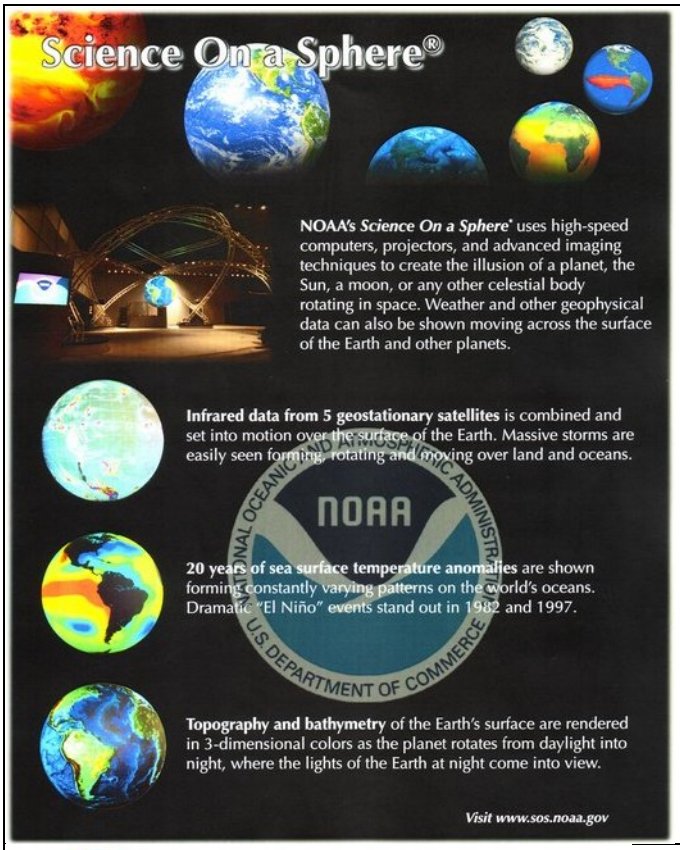
ESRL

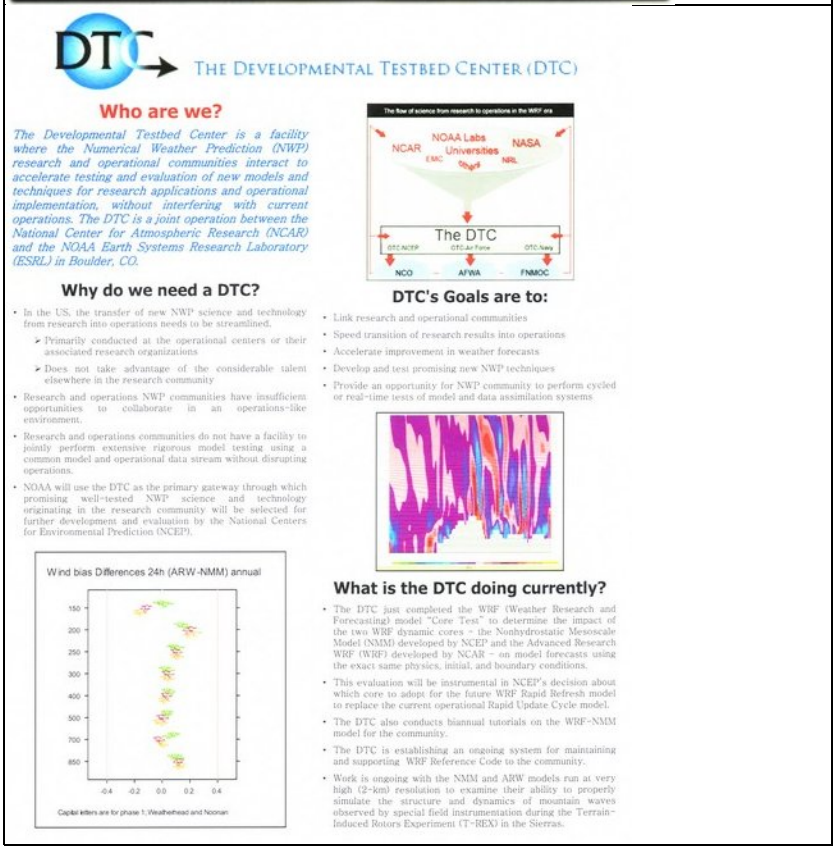
Conceptual Desk-top Prototype



Goal: To develop a low-end, desk-top prototype capability for displaying a wide variety of NOAA data along with other geo-referenced information.

For further information, contact Woody Roberts, NOAA Earth Systems Research Laboratory, Global Systems Division, woody.roberts@noaa.gov


Science On a Sphere®
NOAA's Science On a Sphere® uses high-speed computers, projectors, and advanced imaging techniques to create the illusion of a planet, the Sun, a moon, or any other celestial body rotating in space. Weather and other geophysical data can also be shown moving across the surface of the Earth and other planets.
Infrared data from 5 geostationary satellites is combined and set into motion over the surface of the Earth. Massive storms are easily seen forming, rotating and moving over land and oceans.
NOAA
20 years of sea surface temperature anomalies are shown forming constantly varying patterns on the world's oceans. Dramatic "El Niño" events stand out in 1982 and 1997.
Topography and bathymetry of the Earth's surface are rendered in 3-dimensional colors as the planet rotates from daylight into night, where the lights of the Earth at night come into view.
Visit www.sos.noaa.gov


DTC
THE DEVELOPMENTAL TESTBED CENTER (DTC)
Who are we?
The Developmental Testbed Center is a facility where the Numerical Weather Prediction (NWP) research and operational communities interact to accelerate testing and evaluation of new models and techniques for research applications and operational implementation, without interfering with current operations. The DTC is a joint operation between the National Center for Atmospheric Research (NCAR) and the NOAA Earth Systems Research Laboratory (ESRL) in Boulder, CO.
Why do we need a DTC?
• In the US, the transfer of new NWP science and technology from research into operations needs to be streamlined.
➢ Primarily conducted at the operational centers or their associated research organizations
➢ Does not take advantage of the considerable talent elsewhere in the research community
• Research and operations NWP communities have insufficient opportunities to collaborate in an operations-like environment.
• Research and operations communities do not have a facility to jointly perform extensive rigorous model testing using a common model and operational data stream without disrupting operations.
• NOAA will use the DTC as the primary gateway through which promising well-tested NWP science and technology originating in the research community will be selected for further development and evaluation by the National Centers for Environmental Prediction (NCEP).
NCAR
NOAA Labs
Universities
NASA
NRL
The DTC
NCO
AFWA
FNMOC
DTC's Goals are to:
• Link research and operational communities
• Speed transition of research results into operations
• Accelerate improvement in weather forecasts
• Develop and test promising new NWP techniques
• Provide an opportunity for NWP community to perform cycled or real-time tests of model and data assimilation systems
Wind bias Differences 24h (ARW-NMM) annual
What is the DTC doing currently?
• The DTC just completed the WRF (Weather Research and Forecasting) model "Core Test" to determine the impact of the two WRF dynamic cores - the Nonhydrostatic Mesoscale Model (NMM) developed by NCEP and the Advanced Research WRF (WRF) developed by NCAR - on model forecasts using the exact same physics, initial, and boundary conditions.
• This evaluation will be instrumental in NCEP's decision about which core to adopt for the future WRF Rapid Refresh model to replace the current operational Rapid Update Cycle model.
• The DTC also conducts biannual tutorials on the WRF-NMM model for the community.
• The DTC is establishing an ongoing system for maintaining and supporting WRF Reference Code to the community.
• Work is ongoing with the NMM and ARW models run at very high (2-km) resolution to examine their ability to properly simulate the structure and dynamics of mountain waves observed by special field instrumentation during the Terrain-Induced Rotors Experiment (T-REX) in the Sierras.

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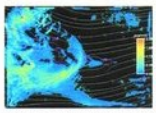
Earth System Research Laboratory

Integrating Research and Technology

ESRL scientists conduct experiments concerning the chemical properties and reactions of atmospheric gases and particles to help improve NOAA's predictions in climate, air quality, and ozone depletion.



Pictured is a 12-hour rain forecast provided by the Weather Research and Forecasting (WRF) model. The WRF model will greatly increase the accuracy and specificity of weather forecasts.

South Pole Observatory

NOAA's Science on a Sphere™ (SOS) enthralls both children and adults as they learn about the land, atmosphere, oceans, and biology of the "whole-Earth" as a system.

1315 East West Highway
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What does the Earth System Research Laboratory do for the Nation?

The mission of the Earth System Research Laboratory (ESRL) is to observe and understand the earth system and to develop products through a commitment to research that will advance the National Oceanic and Atmospheric Administration (NOAA) environmental information and services on global-to-local scales. The work at ESRL includes: understanding the roles of gases and particles that contribute to climate change, providing climate information related to water management decisions, improving weather prediction, understanding the recovery of the stratospheric ozone layer, and developing the next generation of air quality forecast models.

Background

NOAA's Office of Oceanic and Atmospheric Research ("NOAA Research") has consolidated the six organizations of NOAA Research in Boulder, Colorado, into a single center: the Earth System Research Laboratory. This consolidation substantially improves the research and execution of the organizations by having four more-focused Divisions – Global Monitoring, Physical Sciences, Chemical Sciences, and Global Systems – and a more effective and coordinated management structure. The consolidation also will result in better integration of science through the development of research and technology themes that are integrated across Divisions.

Recent Accomplishments:

- Discovered new factors that cause ozone pollution in the Houston, Texas area and observed that leaks of reactive gases from petrochemical refineries prevalent in the region are a much larger factor than were previously expected. **Payoffs: NOAA's research findings regarding ozone pollution in the Houston area have altered the policy approach of Texas air quality managers, improving air quality forecasting in the area and saving 70,000 jobs and $10 billion for the state.**

- Established that forests and agriculture in North America are likely sequestering a sizable portion of the carbon dioxide produced by fossil fuel combustion in the U.S. **Payoffs: This finding indicates that forestry and agricultural practices could be modified to reduce the rate of increase of global carbon dioxide in the atmosphere.**

- Implemented a new and innovative research approach called an observational "testbed" method, which employs a suite of weather observation instruments to determine the best dataset that can be used to improve forecasts of precipitation and runoff in mountainous coastal regions. Such short-term forecasts in coastal areas are not as advanced as those in the interior U.S. because of limited offshore observations and the blockage of conventional weather radar beams by mountains. **Payoffs: The focus on testing new observing capabilities in regional testbeds translates into improvements in NOAA's observing system and forecasts. The improved forecasts have been used, for example, to mitigate the effects of major floods over the U.S. west coast.**

Unmanned Aircraft Systems

Unmanned Aircraft Systems and The Arctic
A National Oceanic and Atmospheric Administration (NOAA) Vision

Over 68 member states, the European Commission and forty-six participating organizations around the world have joined together to coordinate environmental monitoring through the Global Earth Observing System of Systems. As an integral part of this effort, NOAA is moving forward to fill critical gaps in our current measurement systems. Unmanned Aircraft Systems (UAS) can be used to take accurate measurements where current approaches and capabilities are inadequate.

Unmanned aircraft can allow safe high-quality measurements that are critical to improving our understanding of the Arctic. Evidence for a changing Arctic is strong and comes from a variety of sources: satellite measurements, ground-based observations, and inhabitant observations. With the ongoing environmental changes come pressing questions, most notably what will happen in the future? NOAA is interested in improving both short-term predictions of weather and longer estimates of future climate change. Accurate measurements are needed to improve the estimates of future weather and climate, as well as to help scientists understand why the Arctic is changing.

Unmanned aircraft can fill gaps in our current monitoring systems.

What are Unmanned Aircraft Systems?

Unmanned aircraft come in a variety of sizes with new ideas under development from dozens of academic, industry and government groups internationally. They can range in size from small, less than two meters in length, to large, comparable to the size of commercial aircraft. Unmanned aircraft systems include the aircraft, a suite of technology, and teams of people working to support various missions. NOAA currently works with systems that have pilots guiding the aircraft in real time. Pilots on the ground communicate through terminals using information gathered from the aircraft and send commands to control and maneuver the aircraft. NOAA has not chosen a single aircraft, but has tested a number of systems including a high-altitude aircraft and several low-level aircraft. NOAA continues to work with Unmanned Aircraft Systems developing groups on the design and capabilities of the next generation of aircraft.

Unmanned aircraft are designed in sizes as large as commercial aircraft to vehicles less than two meters in length. Each can be used for different purposes in the Arctic.