行政院及所屬各機關出國報告
（ 出國類別: 參與研討會 ）

出席「2004 年第 4 屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議」報告

服務機關：交通部中央氣象局
姓名職稱：丘台光 簡任主任
派赴國家：美國
出國期間：民國 93 年 11 月 7 日至 93 年 11 月 14 日
報告日期：民國 94 年 2 月 1 日

行政院及所屬各機關出國報告提要

系統識別號：C09305235

出國報告名稱：2004 年第四屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議（SPIE Fourth International Asia-Pacific Environmental Remote Sensing Symposium）　頁數 36　含附件：☑是☐否

出國計畫主辦機關/聯絡人/電話

交通部中央氣象局/趙如倩/2349-1012

出國人員姓名/服務機關/單位/職稱/電話

丘台光/交通部中央氣象局/氣象衛星中心/簡任主任/2349-1303

出國類別：☐1 考察☐2 進修☐3 研究☐4 實習☑5 其他

出國期間：民國 93 年 11 月 7 日 至民國 93 年 11 月 14 日　出國地區：美國

報告日期：民國 94 年 2 月 1 日

分類號/目：H8/氣象 H8/氣象

關鍵詞：劇烈天氣監測預報系統(QPESUMS)及區域天氣分析預報系統(LAPS-MM5/WRF)

內容摘要：（二百至三百字）

短時天氣是指未來 0-12 小時發生的天氣變化，又細分爲即時(0-2 小時)及極短時(2-12 小時)天氣，中央氣象局之短時天氣分析與預報系統包含劇烈天氣監測預報子系統(QPESUMS)及區域天氣分析預報子系統(LAPS-MM5/WRF)組成，分別與美國海洋暨大氣總署預報系統實驗室以及國家劇烈風暴實驗室共同合作發展，自 91 年起分階段逐步完成，全部期程 8 年。

職此行的主要任務一方面爲促進國際學術及作業單位瞭解本局短時天氣分析與預報系統技術發展現況，並與國際學者進行意見交流及經驗分享，使本局之極短時預報技術發展業務與國際接軌，提昇本局在相關技術領域之國際能見度。另一方面，藉此了解國際上在大氣、海洋及環境上最新研究發展的遙測技術及未來發展的趨勢，以爲本局未來施政計畫的參考。

本文電子檔已上傳至出國報告資訊網（http://report.gsn.gov.tw）

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服務機關： 交通部中央氣象局
出 國 人　職　　稱： 簡任主任
　　姓　　名： 丘台光

出國地區： 美國
出國期間： 民國 93 年 11 月 7 日至民國 93 年 11 月 14 日
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關鍵詞：劇烈天氣監測預報系統(QPESUMS)、區域天氣分析預報系統(LAPS-MM5/WRF)

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一、 目的

近年來，我國農工商各項建設快速成長，隨著坡地開發及產業行爲的區域集中，使得因天然災害所造成的社經損失不斷增加，其中又以因颱風所帶來豪雨所造成的損失爲最鉅，例如：過去於民國 85 年的賀伯颱風、86 年的溫妮颱風、87 年的瑞伯颱風、89 年的象神颱風及 90 年的桃芝颱風和納莉颱風，都使台灣遭受極大災害損失，而今(93)年因敏督莉颱風所帶來的 72 水災，更重創臺灣中部及南部地區，造成之農業損失達 97 億餘元、工商及國營事業損失達 45 億餘元、全省人員失蹤傷亡達 50 餘人、省及縣道阻斷達 130 餘處，總社經損失更達數百億元。由氣候資料顯示，台灣地區豪雨出現的機率除颱風外，主要發生在梅雨季，每逢梅雨顯著時，常伴隨有局部性豪雨發生，導致嚴重水災或土石流，造成極大的社經損失，對國家經濟建設的成果影響至鉅。有鑑於導致災害的嚴重性與日俱增，豪雨問題普遍受到政府與社會各界的關切。

然而，依世界氣象組織評定，台灣基本上是個潛在水資源匱乏的地區，臺灣水資源的匱乏不在於雨量的稀少，而是雨量分布的不均衡與不穩定，季節間的分布差異大、年際變化也大，又因地形陡峭無法蓄積足夠雨水。而伴隨颱風及梅雨的降雨，卻是台灣地區最重要的用水來源，例如：民國 84 年、91 年及 92 年許多颱風臨台卻未帶來足夠降水，使得全台灣水庫貯水量持續下降造成缺水，從而嚴重影響農耕、部分工業生產及經濟民生。因此，如何在颱風或梅雨等劇烈天氣系統來臨時，有效提供準確的降水資訊，同時供防洪及水資源管理機構進行防災及水庫調節運用，是極爲重要的工作。

常見的劇烈天氣爲豪雨、大雨、大雷雨、冰雹、強風、龍捲風等災害性天氣。特別是由颱風及梅雨鋒面之豪、大雨或強風所引發的災害，幾乎位居台灣地區氣象災害之首位，故劇烈天氣即時預警系統的建立，可有效降低氣象災害對人民的衝擊。又近年來台灣地區遭受天然災害侵襲頻傳，對人民生命、財產造成重大威脅，尤以劇烈天氣引發的氣象災害爲甚。透過發展劇烈天氣監測與預警系統，即時掌握劇烈天氣系統之演變，進行極短時定量天氣預報，適時提供預警，爲本局致力於氣象防災、減災的目標。

有鑑於傳統的天氣預報技術，對災害性劇烈天氣之監測與預報之掌握能力不足，氣象局自民國 91 年起展開「氣候變異與劇烈天氣監測預報系統發展計畫」，其中的「短時預報模式系統」之首要目標，即爲針對梅雨、颱風及豪雨等天氣系統，引進國際先進且成熟的作業技術，並開發符合區域特性的各項相關作業系統，預期在計畫完成後，本局將具備與先進國家

相當之劇烈天氣監測與預報的作業能力。

職此行的主要任務一方面爲促進國際學術及作業單位瞭解本局極短時預報技術發展現況，並與國際學者進行意見交流及經驗分享，使本局之極短時預報技術發展業務與國際接軌，提昇本局在相關技術領域之國際能見度。另一方面藉此了解國際上在大氣海洋及環境上最新研究發展的遙測技術及未來發展的趨勢，以爲本局未來施政計畫的參考。

二、 過程

職此次赴美參加「2004 年第 4 屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議」研討會之行程、地點及簡要內容如下表：

日期	地點與簡要內容
93/11/7	台北→美國夏威夷
93/11/8	「2004 年第 4 屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議」開幕典禮，大會主席 Upendra Singh 及來賓夏威夷大學教授 Peter Englert 致歡迎詞及針對未來遙測衛星及發展技術美國太空總署科學副部長 Ghassem R. Asrar 及美國海洋暨大氣總署下一代軌道衛星計畫主任 John Cunningham 做作 21 世紀美國太空發展面貌及下一代軌道衛星的架構及功能之專題演講。
93/11/9-93/11/11	就大氣、海洋、環境及太空遙測方面，分成「大氣和雲的被動光學遙測」、「雷射遙測在工業及環境上的監測」、「大氣和環境的微波遙測」、「多頻到多功能遙測儀器及應用」、「海洋上主動及被動遙測」、「影像處理及類型辨識」、「衛星在天氣的應用」、「太空遙測的儀器及平台處理技術」、「太空及行星的遙測之儀器及科學及方法」、「全球定位系統遙測的應用」等10大主題單元分別論文報告及討論。
93/11/12	參觀夏威夷大學及自由活動。
93/11/13~93/11/14	美國夏威夷→台北

詳細研討會過程及內容說明如下：

「2004 年第 4 屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議」於 93 年 11 月 8 日在美國夏威夷檀香山市威基基海灘飯店(Waikiki Beach Marriott Resort)大會廳舉行開幕典禮，參加研討會各國代表五百餘人，國際亞太環境大會主席 Upendra Singh 首先致詞歡迎各國代表專家學者能參加共同討論與關心遙測在區域、各國及全球環境監測的問題，並提到第 1 屆國際亞太環境遙測研討會於 1998 年在大陸北京舉行，當時有 16 國家參加，分成 6 大主題報告及討論，而第 2 屆國際亞太環境遙測研討會於 2000 年在日本東京舉行，有 18 國家參加，分成 8 大主題報告及討論，第 3 屆國際亞太環境遙測研討會於 2002 年在大陸杭州舉行，有 23 國家參加，分成 10 大主題報告及討論，而本(第 4)屆在美國夏威夷檀香山市舉行，有 25 國家參加，亦分成 10 大主題報告及討論，參加人數將近 500 人，顯示大家越來越重視遙測在環境監測上更重要的角色，緊接著來賓夏威夷大學教授 Peter Englert 致詞歡迎大家的來訪並預祝大會成功，接著邀請美國航空及太空總署(National Aeronautics and

Space Administration，簡稱 NASA)科學副部長 Ghassem R. Asrar 作 21 世紀美國太空發展面觀，提到很多美國未來發展衛星計畫及伴演的角色，及美國海洋暨大氣總署(National Oceanic and Atmospheric Administration，簡稱 NOAA,)下一代軌道氣象衛星計畫主任 John Cunningham 作下一代軌道衛星系統((National Polar-orbiting Operational Environmental Satellite System，簡稱 NPOESS)的架構及功能之專題演講如附圖 1 至圖 8 所示。會中提到很多下一代軌道衛星的設計的儀器功能及未來應用的效益，原也邀請大陸中國氣科院院士報告中國氣象衛星發展計畫及應用，因簽證問題無法與會。

93 年 11 月 8 日至 11 日，本(第 4)屆研討會分組報告及討論正式展開，亦就大氣、海洋、環境及太空遙測方面分成分 10 大主題同時報告及討論，10 大主題分別爲「大氣和雲的被動光學遙測(Passive Optical Remote Sensing of the Atmosphere and Clouds)」、「雷射遙測在工業及環境上的監測(Lidar Remote Sensing for Industry and Environmental Monitoring)」、「大氣和環境的微波遙測(Microwave Remote Sensing of the Atmosphere and Environment)」、「多頻道多功能遙測儀器及應用(Multispectral and Hyperspectral Remote Sensing Instruments and Applications)」、「海洋上主動及被動遙測(Active and Passive Remote Sensing of the Oceans」、「影像處理及類型辨識(Image Processing and Pattern Recognition in Remote Sensing)」、「衛星在天氣的應用(Applications with Weather Satellites)」、「太空上遙測的儀器及平台處理技術(Enabling Sensor and Platform Technologies for Spaceborne Remote Sensing)」、「太空及行星的遙測之儀器及科學及方法(Instruments, Science and Methods for Geospace and Planetary Remote Sensing)」、「全球定位系統遙測的應用(Remote Sensing Applications of the Global Positioning System)」等。此次參加人數將近 500 人，由於會議發表的文章多達將近 394 篇文章，大會在 4 天的研討會議之議程，共計宣讀論文 307 篇及張貼論文 87 篇。

職被安排在「衛星在天氣的應用」專題單元報告，且此主題亦與本局及本中心主要業務有關，故主要在該主題傾聽所有報告及參與討論，職亦利用空檔時間傾聽「大氣和雲的被動光學遙測」主題部分報告。衛星在天氣的應用主題部份，計有宣讀論文 26 篇及張貼論文 8 篇。進行方式又細分(一)「衛星儀器與反演技術(Instrument/Retrieval Algorithms)」、(二)「日本先進氣象影像特別報告(Special session on Japanese Advanced Meteorological Imager)」、(三)「即時預報與對流(Nowcasting and Convection)」、(四)「資料同化與數值預報(Data Assimilation and NWP)」、(五)「氣候與雲(Climate and Cloud)」等專題依序報

告及討論。以下就每一專題報告及討論過程作一簡要說明，詳細各報告的摘要可參考附錄 1 所示。

(一)「衛星儀器與反演技術」主要探討下一代軌道與同步衛星上儀器之性能、校正及反演的方法，美國繞極軌道作業環境衛星系統(NPOESS)，計畫於 2009 年接替目前的國家海洋暨大氣總署(NOAA)下午 1:30 經過天空的繞極作業環境衛星(POES,Polar Orbiting Environmental Satellite)，於 2011 年接替目前上午 5:30 軌道國防氣象衛星計畫(DMSP,Defense Meteorological Satellite Program) 。NPOESS 衛星軌道高度約 825 至 850 公里，具有 AMSU-A, ARGOS,ATMS, AVHRR/3, CrIS, HIRS/3, MHS, S&R (NOAA), SBUV/3, SEM, VIIRS 等儀器，主要應用在天氣、氣候及其他環境方面如附圖 8 及圖 9。其中 VIIRS 整合 NOAA 的 AVHRR 及 DMSP 上的 OLS 兩種儀器，可產生比 AVHRR 更高解析度的海面溫度及水色。美國同步作業環境衛星系統 GOES-R 未來將具有高解析度多頻道可監測大氣溫度及濕度的重直分佈。

(二)「日本先進氣象影像特別報告」，指出日本預定在明（2005）年發射新一代的地球同步氣象衛星 MTSAT-1R，並在該年年底正式作業，隨後將在 2008 年發射 MTSAT-2 衛星。MTSAT-1R 衛星將增加 1 個觀測頻道，並且增加資料量及提高影像的解析度。在此 MTSAT-1R 作業後與 MTSAT-2 作業前的過渡時期，將以原來 GMS-5 的資料格式與新的 MTSAT 資料格式同時廣播。在 2008 年以後將以全新的信號格式傳送衛星資料，停用原來的格式，也就是衛星中心原來的接收系統將無法繼續使用。在資料量增加，傳輸速率提高及廣播格式變更的情形下，衛星接收處理設備的更新顯得更迫切。

(三)「即時預報與對流」主要如何利用水氣頻道與紅外線分析與追蹤對流系統移動及發展，並利用衛星及雷達資料發展熱帶降水潛勢方法之應用，另利用美國新一代同步作業環境衛星系統 GOES-R 之高解析度溫濕資料加入，提升即時預報對流技術之改進技術。

(四)「資料同化與數值預報」主要報告如何利用各種軌道及同步衛星資料，透過同化技術加入到數值模式，提升未來 3 至 5 天數值預報的能力及颱風路徑預報的準確率。

(五)「氣候與雲」則探討利用新一代 AVHRR 資料作雲氣候特徵分析，利用軌道衛星資料作海溫及氣懸膠反演研究，利用作業 GOES9 同步衛星資料資料探討東亞熱帶地區沙塵暴的監測，以及利用地球觀測衛星資料反演更高解析度植被指數及雲特性之研究。

另外職也利用空檔去旁聽「大氣和雲的被動光學遙測」主題單元之部分報告內容，主要提到目前地球觀測衛星上以及未來新一代軌道衛星上都有很多被動光學監測環境的儀器，如何利用此先進開發的儀器在氣象、環境汙染、地表及海洋環境的監測以及水氣重直分佈等應用上伴演很重要的角色。

職被安排在「資料同化與數值預報」專題單元報告，報告的題目是中央氣象局極短時預報系統現況及未來發展，詳細內容可參考附錄 2，由於結合遙測資料(衛星及雷達)、資料同化技術及數值模式之整合，並測試應用到劇烈天氣作業上，反應非常熱烈，報告完後很多美國海洋大氣總暑專家及學者上前致意，都認爲台灣中央氣象局在開發極短時劇烈天氣的監測與預報方面很有成效及進度，以下就報告中主要內容以中文簡要說明如下：

中央氣象局與美國劇烈風暴實驗室(National Severe Storms Laboratory; NSSL)於2002 年起開發劇烈天氣監測系統，提供對於劇烈對流及突變天氣的即時監測，有效利用雷達、衛星及雨量計等多重觀測資料以準確估計降雨型態及降雨強度(Quantitative Precipitation Estimation and Segregation Using Multiple Sensors; QPESUMS)，並透過風暴偵測分析技術的開發，提昇本局人員對於劇烈或突變天氣之監測預警的能力，並逐步推廣至到防救災作業中心。

在定量降雨估計方面，中央氣象局所屬五分山、花蓮、七股及墾丁雷達在經過去除地形雜波、海面回波及非正常傳播之後，依各雷達不同方位的觀測，整合最接近地面且不受地形阻擋與影響的仰角觀測資料，即最低仰角合成回波資料。最後應用 $Z-R$ 關係式進行降雨強度與累積降雨量的推估。有鑑於下游水文單位，現已開發出小區域的流域雨量產品，使高解析度的定量降雨資訊，達到最充分的應用。使用最低仰角合成回波及利用地面雨量站校正雷達降雨估計來求取 $Z-R$ 關係式，則可降低不同系統間的個別差異及提高雷達估計雨量與實際降雨量間的相關。以造成台灣中南部嚴重災害的敏督莉颱風(2004)爲例，由各流域區域平均時雨量＞5 mm/hr 的 Bias(R_a/G_a，R_a爲該區各網格點上雷達回波估計之時降雨量平均，G_a爲該區雨量站量測之時降雨量之平均)顯示在會降下較大雨量的天氣系統中，且在不經地面雨量站較驗的情況下，已具有Bias 接近1的良好相關，其中位於東部的第9區南澳河系因爲無＞5 mm/hr 之平均時雨量，則出現 Bias 爲 0 的情況。

爲達防災減災的目的，監測劇烈天氣或突變天氣系統是各作業單位的採用趨勢，利用雷達回波追蹤相關技術的開發，準確預報系統的移向移速，若其他氣象、工程、防災、水利及水庫管理等單位再善加利用定量降水資訊，進行河川流量與水位的預測，則可掌握侵犯時間及其所造成的災害程度，如此可望提昇對於短時劇烈天氣系統的監測及預警能力，並達成台

灣本島及其鄰近海域降水定量化的目標。在劇烈風暴偵測方面，有組織雷暴之中尺度對流系統可有效線性外延 1~2 小時，可增加預警時間及預報能力。因此，當梅雨鋒面及颱風系統中的中尺度對流系統，以及熱對系統，監測系統能即時提供其對流胞定位資訊，如移向移速、最大回波值及其所在高度、垂直液態水含量、冰雹及龍捲風發生機率，以及冰雹大小，並進行對流胞的追蹤與短時間的對流胞位置外延。另外，於颱風系統接近台灣本島鄰近海域時，監測系統可即時提供颱風中心定位資訊，隨時掌握颱風結構與對流雨帶的變化，對其會帶給台灣的影響保持警戒。

未來本系統將持續改進定量水估計的品質，並利用模式分析場與外延技術，進行 0-2 小時的定量降水預報。在下游應用方面，本局並將廣泛推廣至防救災單位，並配合下游水文單位進行相關產品的開發，以發揮本監測系統在防災作業上最大的功效。在劇烈風暴偵測與追蹤方面，本系統將朝警訊系統開發方向努力，並希望透過多重發布管道，將危險天氣的訊息迅速傳達到防救災單位與一般民眾，以使可能造成的氣象災害降至最低。而局地天氣分析及預報模式，將引進非絕熱初始化技術應用在高解析數值預報模式內，以提供 2-12 小時劇烈天氣預報產品。

三、 心得

這次職第 1 次參加由 SPIE 主辦的「2004 年第 4 屆國際亞太環境遙測研討會：大氣、海洋、環境及太空遙測組會議」，自 11 月 8 日開始，到 11 月 12 日結束，議程安排十分緊湊而充實。5 天研討主題包括「大氣和雲的被動光學遙測」、「雷射遙測在工業及環境上的監測」、「大氣和環境的微波遙測」、「多頻道多功能遙測儀器及應用」、「海洋上主動及被動遙測」、「影像處理及類型辨識」、「衛星在天氣的應用」、「太空上遙測的儀器及平台處理技術」、「太空及行星的遙測之儀器及科學及方法」、「全球定位系統遙測的應用」等 10 大主題同時報告與討論，共宣讀 307 篇論文，另有 87 篇張貼論文報告。職全程參與「衛星在天氣的應用」主題單元所有論文的報告及討論，並利用空檔旁聽「大氣和雲的被動光學遙測」主題單元部分報告，發現無論美國或歐洲先進國家，不但對即時預報或短期預報提供一很好觀測工具，對於雲量的偵測、長期氣候的監測，地表及海洋資源之運用亦有很大幫助，尤其衛星水氣風場、雲量的分類及微波在大氣溫溼剖面與降水估計之應用，更提供一很好的觀測資料，不但對廣大洋面上增加很多有用的資料，並且對數值預報改進模式的初始化及預報准準確力提升都有很大的幫助。此外，也發現歐洲氣象衛星開發組織對繞極軌道氣象衛星的使用比美國方面應用更廣，對於大地及海洋資源的利用與開發亦更積極，令人印象深刻。

特別值得一提的，由於中央氣象局過去從未參與由 SPIE 所主辦的研討會，此次職特別就中央氣象局在極短時監測與預報上所發展的系統作介紹，讓與會國際上學術及作業單位學者專家，瞭解本局短時天氣分析與預報系統技術發展現況並與國際學者進行意見交流及經驗分享，使本局之極短時預報技術發展業務與國際接軌，提昇本局在相關技術領域之國際能見度。另一方面，藉此了解國際上在大氣、海洋及環境上最新研究發展的遙測技術及未來發展的趨勢，以爲本局未來施政計畫的參考。

四、 建議

第 1 屆國際亞太環境遙測研討會於 1998 年在大陸北京舉行，當時有 16 國家參加，分成六大主題報告及討論，而第 2 屆國際亞太環境遙測研討會於 2000 年在日本東京舉行，有 18 國家參加，分成 8 大主題報告及討論，第 3 屆國際亞太環境遙測研討會於 2002 年在大陸杭州舉行，有 23 國家參加，分成 10 大主題報告及討論，而本第 4 屆在美國夏威夷檀香山市舉行，有 25 國家參加，亦分成 10 大主題報告及討論，參加人數將近 500 人，顯示大家越來越重視遙測科技在環境監測上扮演更重要的角色。

中央氣象局之短時天氣分析與預報系統包含劇烈天氣監測預報子系統(QPESUMS)及區域天氣分析預報子系統(LAPS-MM5/WRF)組成，分別與美國海洋暨大氣總署預報系統實驗室及國家劇烈風暴實驗室共同合作發展，自 91 年起分階段逐步完成，全部期程 8 年。職此次參加國際亞太環境遙測研討會，一方面在促進國際學術及作業單位瞭解本局短時天氣分析與預報系統技術發展現況及未來展望，使本局之極短時預報技術發展業務與國際接軌，提昇本局在相關技術領域之國際能見度。另一方面，藉此了解國際上在大氣、海洋及環境上最新研究發展的遙測技術及未來發展的趨勢，以爲本局未來施政計畫的參考。雖然是第 1 次參加，但由於事前準備充分及積極參與會議討論與報告，成果收穫豐碩，茲有以下幾點建議：

1.利用地球觀測衛星資料(紅外線、可見光、水氣及微波頻道)所導出雲特性，海溫、森林火災、沙塵暴，空氣污染等環境監測方面的技術已成熟，美國、日本及歐州國家等先進國家都逐步正式納入正常作業，我國已與美國航空暨太空總署及威斯康辛州氣象衛星研究中心科學家合作引進該項技術，預計 2 年內完成。

2.美國國家氣象中心及歐州聯盟數值預報中心等先進國家，已充分利用各種軌道及同步衛星資料，透過 3 維同化技術加入到數值模式測試及改進，已明顯顯示可提升未來 3 至 5 天日常數值天氣預報及颱風路徑預報的準確率，我國正起步，有待加油。

3. 2009 年將發射下一代繞極軌道氣象衛星 NPOESS 系列的第 1 顆，完全取代現在的 NOAA 衛星系列，提供更佳品質的大氣觀測。NPOESS 將結合現在的 NOAA，DMSP(美國國防氣象衛星)及 LANDSAT(地球資源衛星)3 種衛星於一體也就是集合了這 3 個衛星的特色。原來的下午的 NOAA 衛星將由歐洲衛星組織主導的 METOP 衛星系列取代。原來以 L Band 廣播的頻道爲了更大的資料量改變爲 X Band 廣播，觀測儀器的頻道也由數十個增加到數千個。中央氣象局已因應訂定未來衛星系統更新及產品應用技術開發之計畫報部轉院，寄望政府能大力支持，

以提升我國氣象衛星遙測之發展。

4. 國際亞太環境遙測研討會每 2 年舉辦 1 次，每次研討會均有很豐富的新技術、新產品提出，透過人員的參與不但可了解先進國家在大氣、海洋、環境及太空遙測遙測發展情況，亦可吸收一些新的資訊與技術，促進我國遙測技術方面提升，故非常值得繼續派員參加。

5. 這次參加研討會，更深切体會由於科技及電腦的進步，很多新開發的產品及應用的技術，都可透過合作或共享方式透過網際網路(WWW)獲得全球地球觀測衛星資料，此對氣候環境監測上非常需要，若能建立及充分善用此機制，將可對推動業務上有很大幫助。

6. 氣象衛星資料的應用隨著新儀器新頻道的增加，不管在資料量、準確度以及應用方面都大爲提升，各先進國家無不投入大量的人力及經費，反觀我國不管在作業上及研究上，由於政府精簡政策下，人力與經費投入不足，此點值得我們深思。

附圖

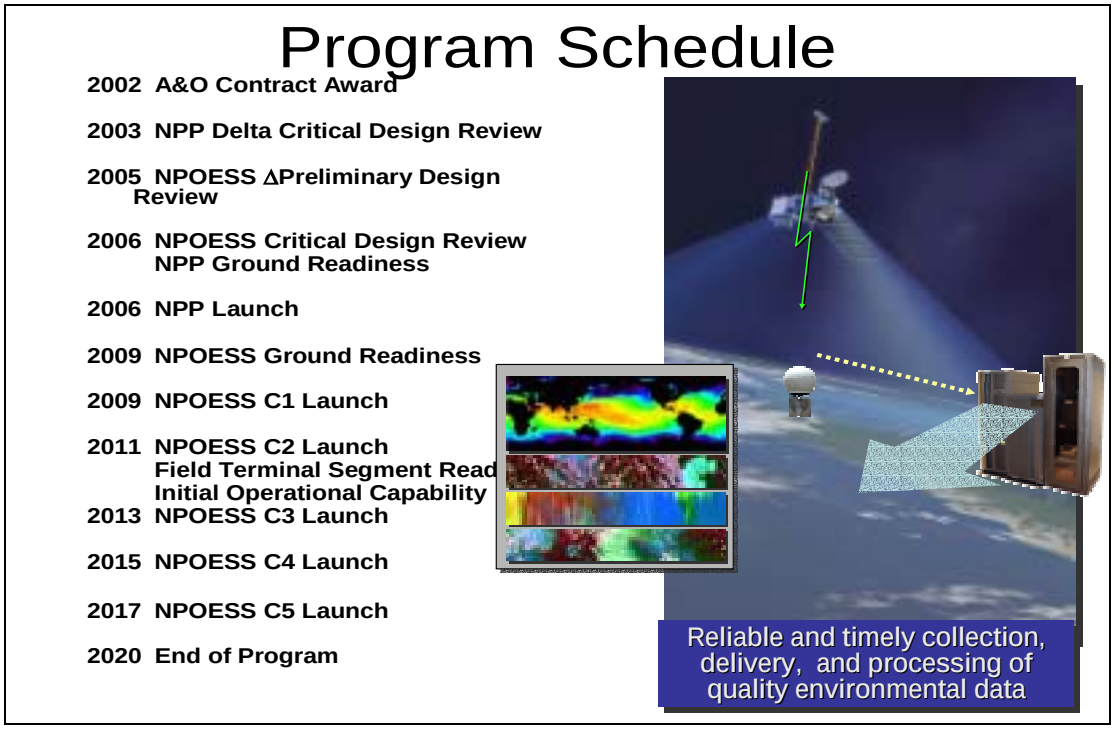


圖 1：下一代軌道衛星計畫時程

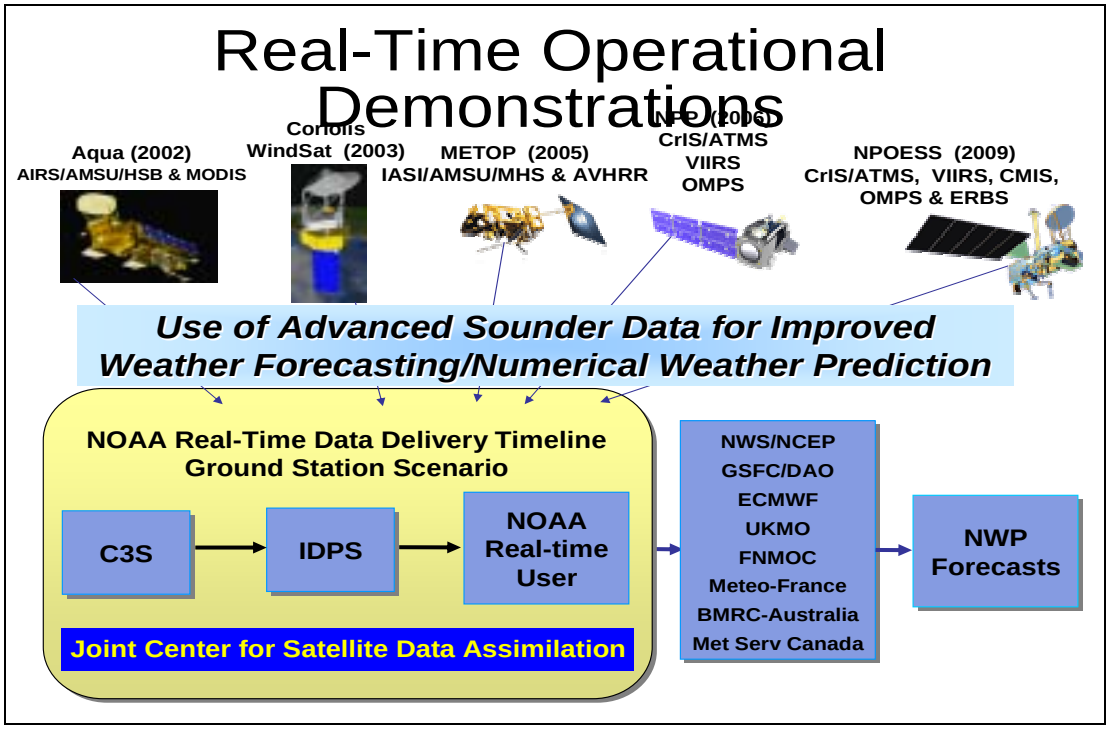


圖2：利用先進衛星資料透過同化科技改進數值天氣預報季架構圖

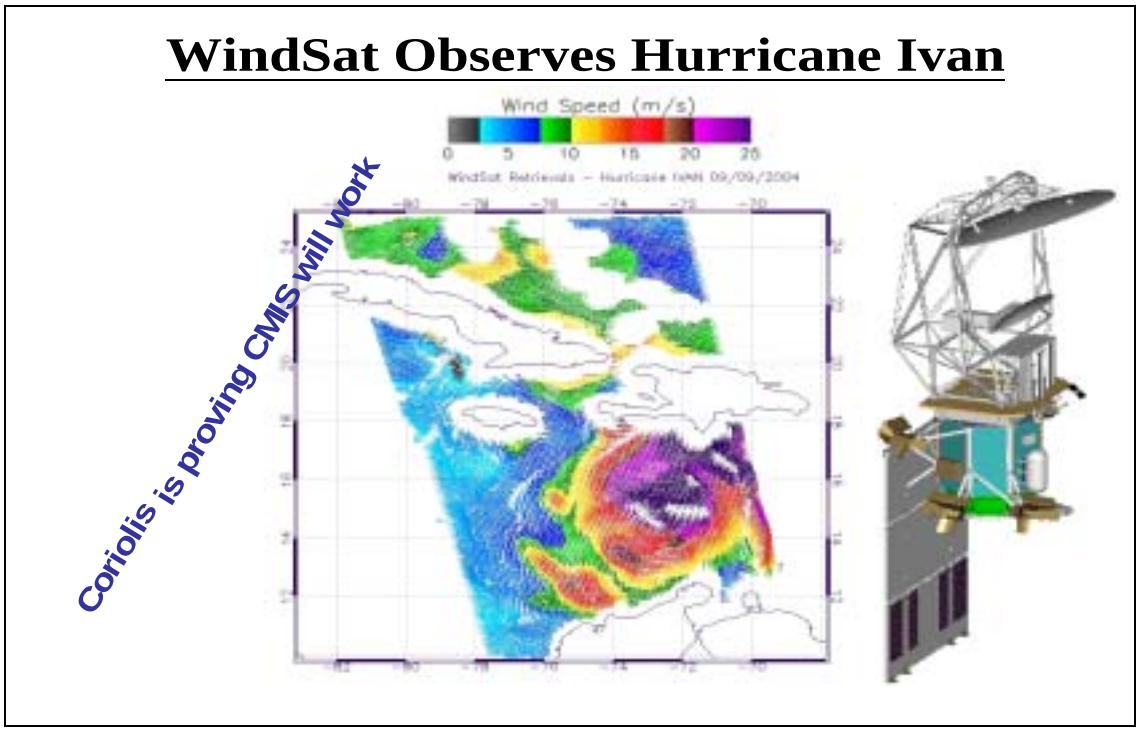


圖 3:「衛星風」觀測颱風 Ivan 海面風資料

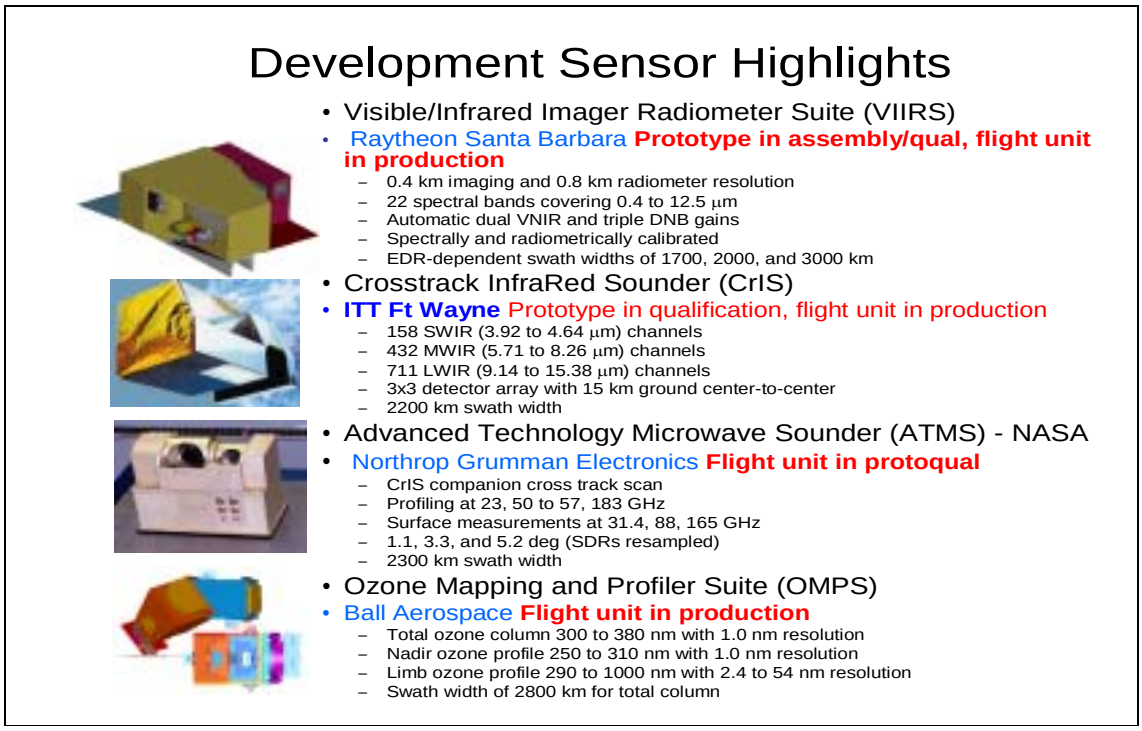


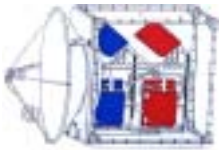
圖 4:新一代軌道衛星 NPOESS 中所發展儀器之概況

Development Sensor Highlights (cont.)

- Conical Scanning Microwave Imager/Sounder (CMIS)
  Boeing Space Systems **Delta PDR complete**
  - 2.2 m antenna
  - RF imaging at 6, 10, 18, 36, 90, and 166 GHz
  - Profiling at 23, 50 to 60, 183 GHz
  - Polarimetry at 10, 18, 36 GHz
  - 1700 km swath width
  - Radio Interference (RFI) ECP complete, negotiations being wrapped up

圖 5：續圖 4

Leverage Sensor Highlights



- Radar Altimeter (ALT)
- Alcatel
  - Measures range to ocean surface with a radar at 13.5 GHz
  - Corrects for ionosphere with 5.3 GHz radar
  - Corrects for atmosphere with CMIS water vapor measurements
  - Precise orbit determination with GPS
- Earth's Radiation Budget Suite (ERBS)
- Northrop Grumman Space Technology
  - Three spectral channels
  - Total radiation measurement 0.3 to 50 μm
  - Shortwave Vis and IR measurement 0.3 to 5 μm
  - Longwave IR measurement 8 to 12 μm
- Total Solar Irradiance Sensor (TSIS)
- University of Colorado **Agreements in place, design underway**
  - Two sensors for total irradiance (TIM) & spectral irradiance (SIM)
    - TIM measures total solar irradiance
    - SIM measures spectral irradiance 200 to 2000 nm
  - Pointing platform and sensor suite to be provided by CU LASP
- Survivability Sensor (SS)

圖6：續圖4

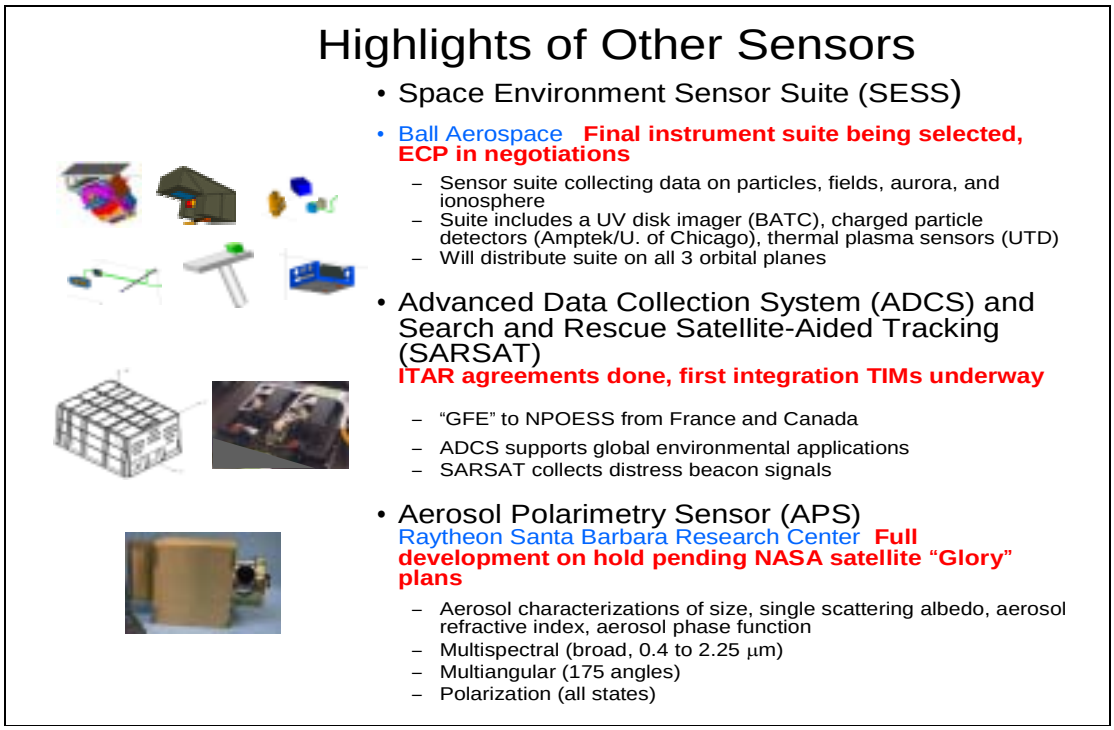


圖 7：新一代軌道衛星 NPOESS 其他觀測儀器概況

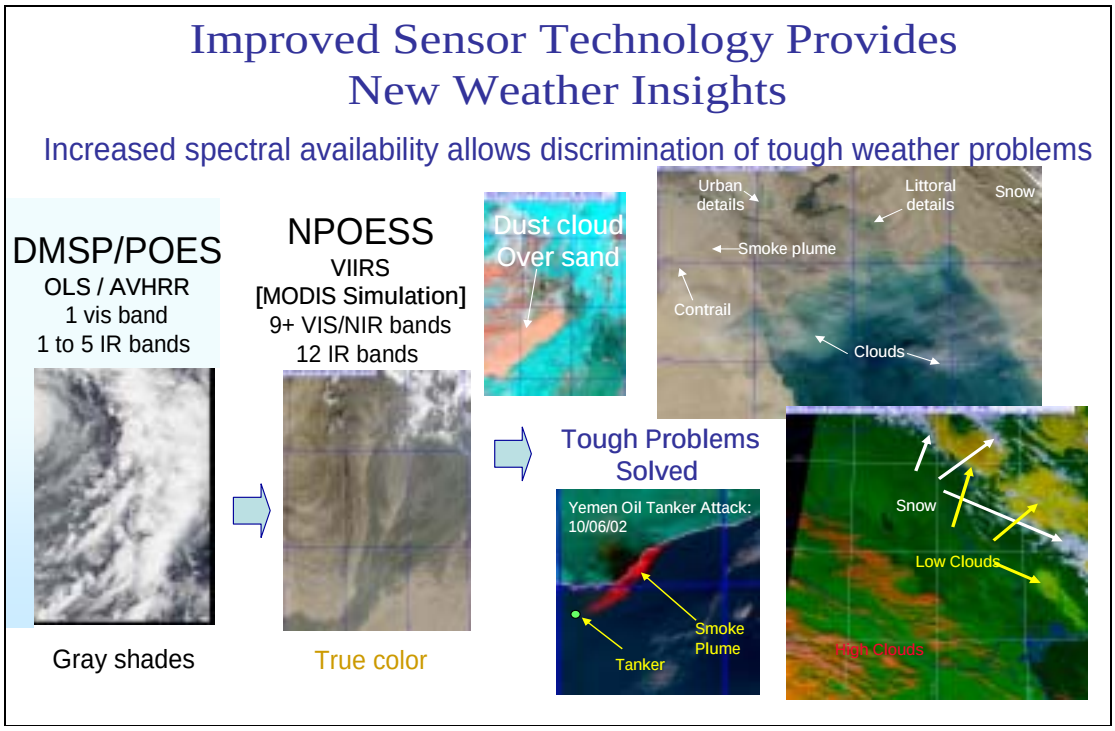


圖8：衛星儀器之改進可提供新天氣監測產品應用

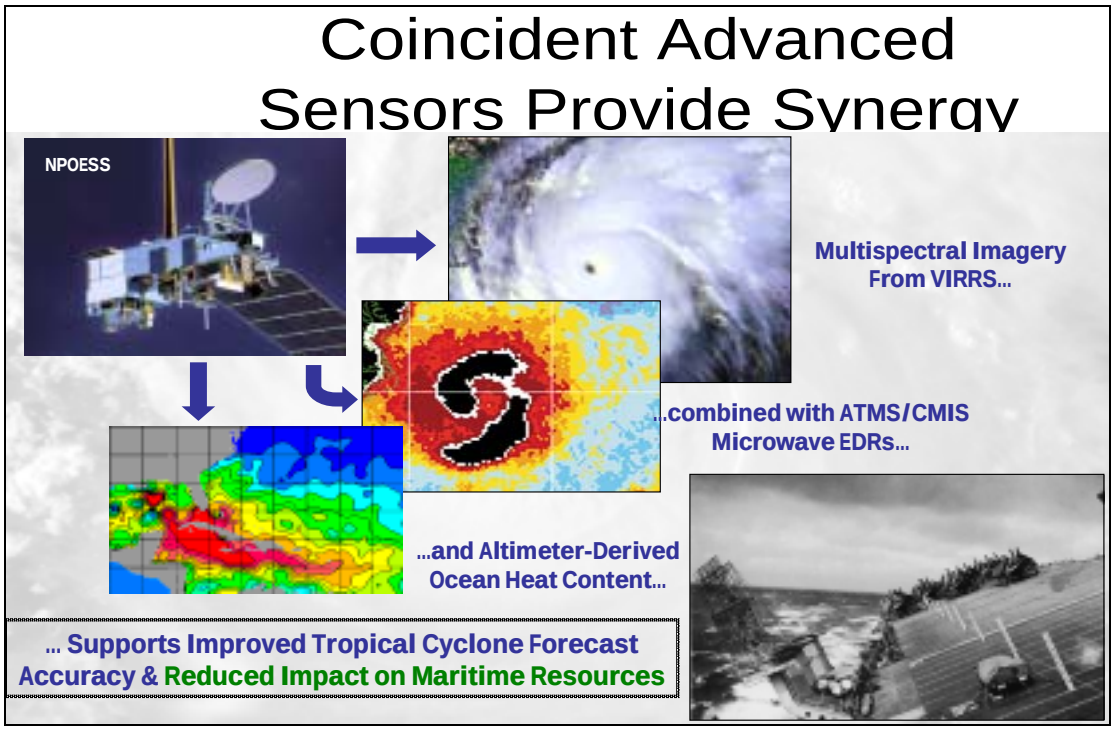


圖 9：新一代軌道衛星 NPOESS 發展之效益

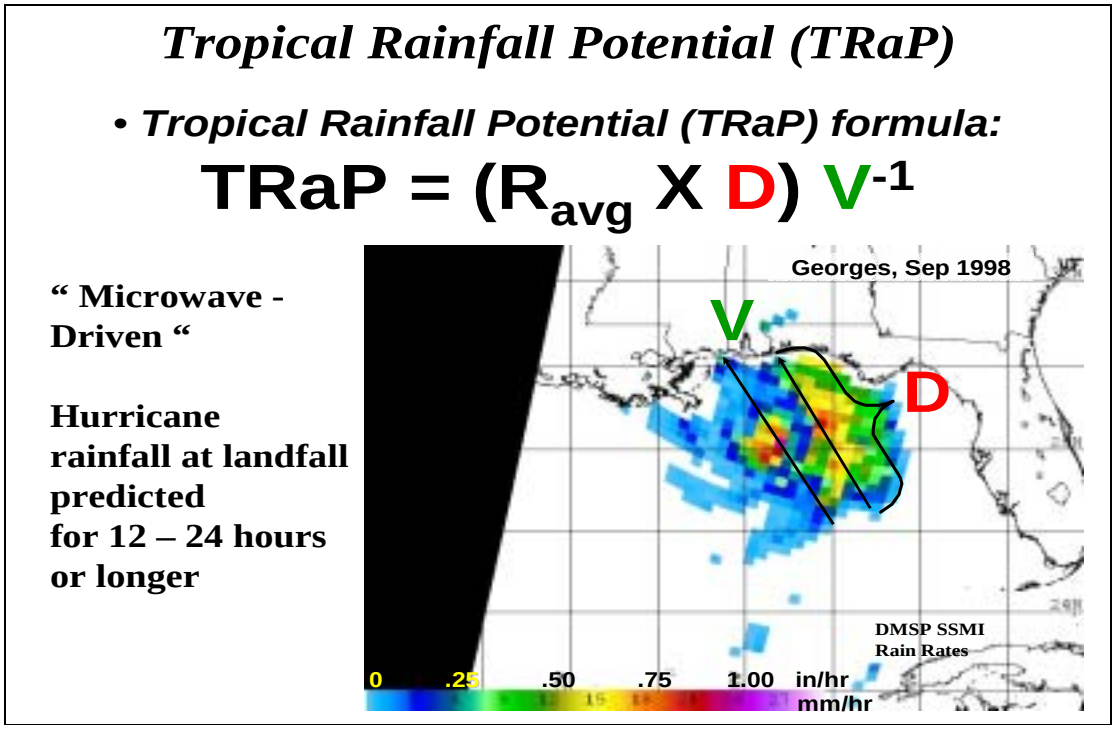


圖10：利用衛星資料作熱帶降水潛勢預估

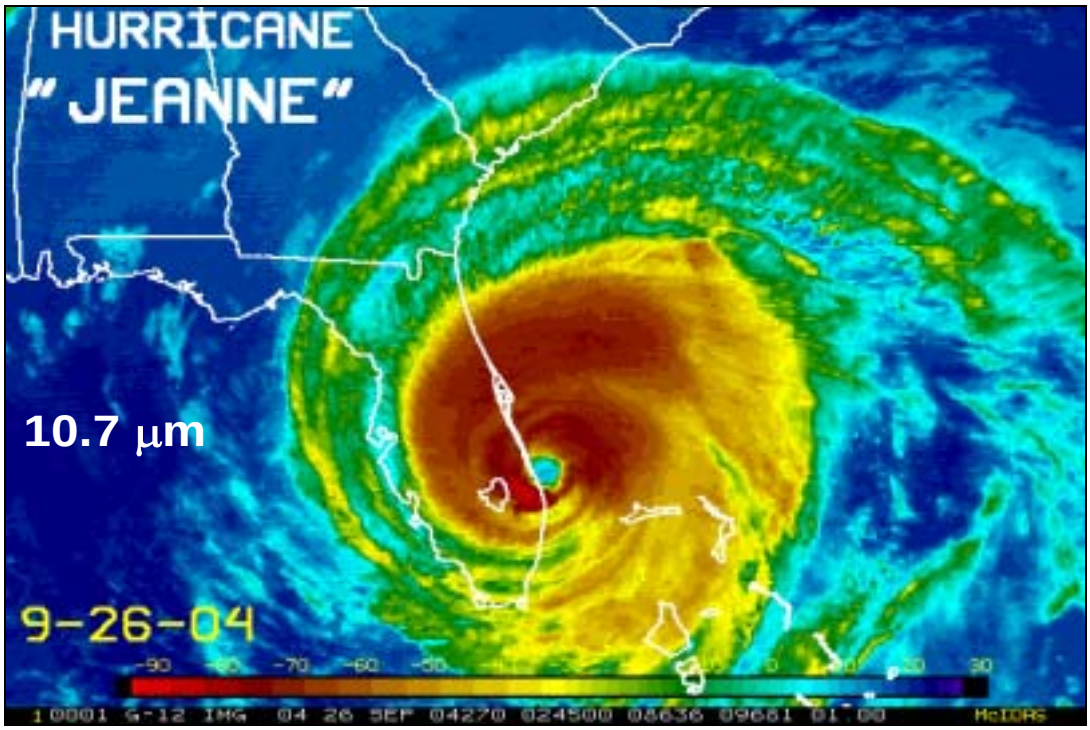


圖11：颱風Jeanne登陸前紅外線雲圖特徵

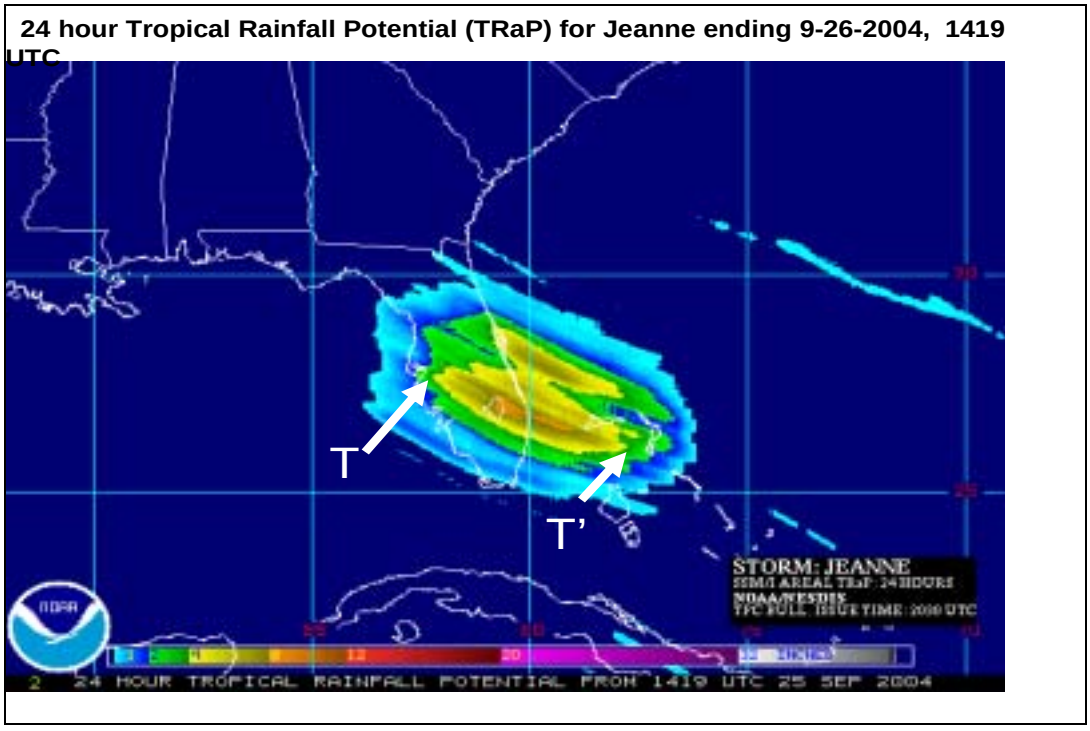


圖12：利用颱風Jeanne登陸前紅外線雲圖資料，作24小時熱帶降水潛勢預估結果

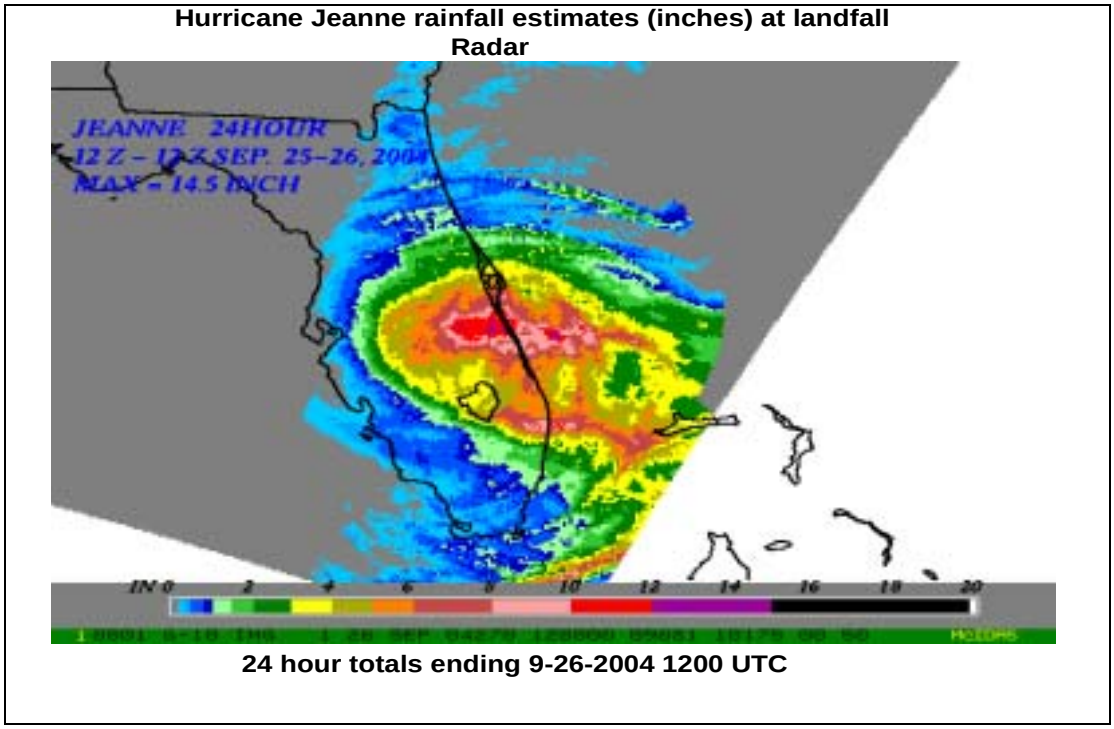


圖13：利用雷達資料作24小時颱風Jeanne降水估計結果

附錄1：氣象衛星在天氣之應用論文集摘要

Conference 5658: Applications with Weather Satellites IB

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5658-31, Poster Session

Cloud classification products derived from operational imagers

M. J. Pavolonis, Univ. of Wisconsin/Madison; A. K. Heidinger, National Oceanic and Atmospheric Administration

Cloud classification products for several operational imagers are presented. The cloud classification categories includes fog, water cloud, supercooled water/mixed phase cloud, opaque ice cloud, non-opaque ice cloud (cirrus), and multi-layered clouds. Results from the AVHRR, GOES-io, GOES-12, and MODIS, which is the prototype for the future operational polar-orbiting im-ager VIIRS, will be shown. Different techniques are used to accommodate the differences in the spectral channels that are available on each imager. Validation of each of these products is also presented.

5658-32, Poster Session

The global distribution of cloud type from operational polar-orbiting imagers

M. j. Pavolonis, Univ. of Wisconsin/Madison; A. K. Heidinger, National Oceanic and Atmospheric Administration

The global distribution of different cloud types will be analyzed. Results from an AVHRR algorithm, used operationally in NOAA's CLAVR-x system, and an algorithm built for the VIIRS, which will replace the AVHRR on the next generation operational polar-orbiting platform (the NPOESS platform), are presented using MODIS data. The cloud type classification includes, water cloud, supercooled water/mixed phase cloud, opaque ice cloud, non-opaque ice cloud (cirrus), and multi-layered cloud systems. The VIIRS algorithm, which utilizes additional spectral channels that are not available on the AVHRR, is much more effective at correctly identifying cirrus cloud, cloud overlap, and determingthe phase of thin low and mid-level clouds.

5658-34, Poster Session

In-flight measurements of space count in the AVHRR solar reflectance bands

A. Ignatov, C. Cao, J. T. Sullivan, R. H. Levin, X. Wu, National Oceanic and Atmospheric Administration; R. P. Galvin, ITT Aerospace/ Communications

The solar reflectance bands (SRB) centered at ?1=o.63,72=0.83, and ?3A=1.61 [xm of the Advanced Very High Resolution Radiometers (AVHRR) flown onboard NOAA satellites are often referred to as non-calibrated in-flight. In contrast, the Earth emission bands (EEB) centered at 736=3.7,74=11, and 75=12 *an* are calibrated using two reference points, deep space and the internal calibration target. In the SRBs, measurements of space count (SC) are also available, however, historically they are not used to specify the calibration offset ("zero count", ZC), which does not even appear in the calibration equation. A regression calibration formulation is used instead, equivalent to setting the ZC to a constant, whose value is often specified from pre-launch measurements.

Our analyses below, supported by a review of the instrument design and a wealth of historical SC information, show that the SC varies in-flight and differs from its pre-launch value. We therefore suggest that (i) the AVHRR calibration equation in the SRBs be re-formulated to explicitly use the ZC, consistently with the EEBs, and (2) the value of ZC be specified from the onboard measurements of SC. The ZC-formulation of the calibration equation is physically solid, and it minimizes human-induced calibration errors resulting from the use of a regression formulation with an un-constrained intercept. Specifying the calibration offset improves radiances, most notably at the low end of radiometric scale, and subsequently provides for more accurate vicarious determinations of the calibration slope (gain). These calibration improvements are important for the products derived from the AVHRR low-radiances, such as aerosol over ocean, and particularly critical when generating their long-term climate data records (CDR).

5658-35, Poster Session

Arctic climate characteristics and recent trends from space

X. Wang, Univ. of Wisconsin/Madison; j. R. Key, National Oceanic and Atmospheric Administration

The newly available Advanced Very High Resolution Radiometer (AVHRR) Polar Pathfinder (APP) data has been extended to create a comprehensive data set, called APP-x, containing cloud microphysical properties, surface temperature and broadband albedo, radiation fluxes and cloud forcing over the Arctic and Antarctic for the 19-year period 1982-2000.

The APP-x data show that the annual mean cloud coverage in the Arctic is about 70%, with a maximum in September and a minimum in April. Arctic cloud optical depth averages about 5 - 6. The largest downwelling shortwave radiation flux at the surface occurs in June; the largest upwelling shortwave flux occurs in May. The largest downwelling and upwelling longwave and net radiation fluxes occur in July, with the largest loss of longwave radiation from the surface in April.

Over the past 20 years, the Arctic has warmed and become cloudier in spring and summer, but has cooled and become less cloudy in winter. The decadal rate of annual surface temperature change is O.57C for the area north of 6oN. The surface broadband albedo has decreased at a decadal rate of -1.5% (absolute). Cloud fraction has decreased at a decadal rate of 6% (absolute) in winter, and increased at decadal rates of 3.2% and 1.6% in spring and summer, respectively. On an annual time scale, net cloud forcing at the surface has decreased at a decadal rate of -3.35 W/m2, indicating an increased cooling by clouds. There are large correlations between surface temperature anomalies and climate indices such as the Arctic Oscillation (AO) index for some areas, implying linkages between global climate change and Arctic climate change.

5658-36, Poster Session

Bias correction of microwave radiances for data assimilation

W. F. Campbell, N. L. Baker, C. B. Blankenship, Naval Research Lab.

Temperature retrievals from polar-orbitingsatellitesare clearly beneficial in the Southern Hemisphere (S.H.) and the stratosphere, due to lack of conventional data, but consistent positive impact on Northern Hemisphere (N.H.) forecasts has been difficult to demonstrate. The retrieval problem is formally ill-posed, and the errors in retrievals are complex and difficult to characterize.

An alternative to retrievals is the direct assimilation of radiance data. The NRL Variational Data Assimilation System (NAVDAS) coupled with the Navy Operational Global Atmospheric Prediction System (NOGAPS), constitute a system capable of three-dimensional variational assimilation (3DVar) of radiance data in observation space. Major weather centers worldwide have shown significant increases in forecast skill by adopting direct radiance assimilation. In particular, the assimilation of microwave radiance data from the Advanced Microwave Sounding Unit (AMSU-A) temperature sounder has shown clear positive impact in both hemispheres at the Naval Research Laboratory (NRL) and Fleet Numerical Meteorology and Oceanography Center (FNMOC).

One crucial component of direct radiance assimilation is bias correction, relative to any given forecast model. We must correct for biases due to the satellite instrument, and biases due to the underlying airmass, resulting from inaccuracies in the fast radiative transfer model used to convert NWP model fields into simulated radiances. Our approach to air-mass bias correction, based on Harris & Kelly, 1999, uses multilinear regression of two weeks of observed minus computed radiance statistics, with selected NWP fields as predictors. We are actively pursuing research into hybrid methods, which add the radiances themselves as predictors.

Bias correction can aid in retrievals as well. We will present preliminary results comparing uncorrected and bias-corrected AMSU-B moisture retrievals, and show that the differences are nontrivial.

New instruments are being launched all the time, and the need for bias correction is universal. The methodology used at NRL is robust and general, and should be applicable to current and future satellites. We hope to have preliminary results for the Special Sensor Microwave Imager/Sounder (SSMIS) bias correction, so that we can compare how well our methods work with different instruments, and with the same instrument on different platforms.

5658-37, Poster Session

Design concept for a Wedge-filter Imaging Sounder for Humidity (WISH): a practical NPOESS PS! and geostationary Earth orbit high-spatial resolution sensor

J. J. Puschell, Raytheon Space and Airborne Systems

Tropospheric wind is among the top priority NPOESS Pre-Planned Product Improvement (P3I) EDR candidates. This EDRcan be retrieved by tracking high spatial resolution attitude-resolved water vapor sounding features in imagery at appropriate temporal sampling provided by a humidity imaging sounder. A Wedge-filter Imaging Sounder (WIS) can provide the required humidity imagery and has already been studied for application in geostationary orbit by Puschell, Huang and Woolf. The geostationary WIS would use spatially variable wedge filter spectrometers to collect earth radiance with -2 km resolution over a broad infrared (710-2900 cm-i) spectral region at 1% spectral resolution. The resulting sensor is a compact, lightweight, and rugged imaging sounder with better sensitivity, spectral resolution, spatial resolution and full disk coverage time than the current multispectral GOES imager. Wedge-filter Imaging Sounder for Humidity (WISH) incorporates the same Raytheon WIS technology and is suitable for flight on the NPOESS C-2 or €-3 spacecraft. WISH would take advantage of the payload capacity available for P$I demonstrations in NPOESS and would serve as a risk reduction and technology demonstration for future NOAA environmental satellite missions. In this paper, we present our analysis of WISH sensor concept design, specification and expected radiometric sensitivity. The practicality of WISH for the current NPOESS LTAN spacecraft configuration will also be discussed. The performance of WISH toward achieving NPOESS P3I's tropospheric wind objective will be discussed in a companion paper by Huang et al.

5658-38, Poster Session

Global cloud cover trends inferred from 22 years of HIRS observations

W. P. Menzel, National Oceanic and Atmospheric Administration; D. P. Wylie, Univ. of Wisconsin/Madison

Cloud cover information and the frequency of upper tropospheric clouds have been extracted from NOAA/HIRS polar orbiting satellite data from 1979 to 2001. The HIRS-2 sensor was flown on nine satellites from TIROS-N through NOAA 14 during this time forming a consistent 22-year record. C02 slicing was used to infer cloud amount and height. Trends in cloud cover and high cloud frequency are small in these data. High clouds show small but statistically significant increasing trends in the tropics and northern hemisphere. The HIRS analysis contrasts from that from the ISCCP which shows decreasing trends in both total cloud cover and high clouds during most of this period. The HIRS detection of upper tropospheric thin cirrus creates most of the difference with respect to ISCCP; GLAS observations of high thin clouds are largely in agreement with the HIRS.

5658-01, Session 1

NPOESS VIIRS: dramatically improved operational capability

]. D. Hawkins, S. D. Miller, Naval Research Lab.; C. Schueler, Raytheon Santa Barbara Remote Sensing; F. J. Turk, T. F. Lee, K. Richardson, Naval Research Lab.; J. Kent, Science Applications International Corp.

The National Polar-orbiting Operational Environmental Satellite System
(NPOESS) Visible Infrared Imager/Radiometer Suite (VIIRS) is approaching its first launch (2006) on the NPOESS Preparatory Project (NPP) satellite. The VIIRS design will offer dramatic improvements in spectroradiometry and spatial resolution over predecessor polar

operational instrumentation. The currently operating Polar-orbiting Operational Environmental Satellite (POES) Advanced Very High Resolution Radiometer (AVHRR) and the Defense Meteorological Satellite Program (DMSP) Operational Line-scan System (OLS) capabilities for atmospheric, land, and ocean measurements have been combined into enhanced VIIRS requirements at finer spatial resolution and better accuracy. VIIRS must also provide ocean color/chlorophyll measurements which neither AVHRR nor OLS were designed to support. All in all, VIIRS dramatically enhances over twenty Environmental Data Records (EDRs) compared to the current operational system.

Many of these improvements have been partially demonstrated usingthe Earth Observing System (EOS) MODerate-resolution Imaging Spectroradiometer (MODIS) instrument, which has been operating on the NASA EOS Terra and Aqua research satellites since 1999 and 2002 respectively. While MODIS does not offer all of the improvements VIIRS provides relative to OLS, MODIS does offer the substantial spectroradiometric advantages that the VIIRS design offers, and therefore it is possible to simulate many of the dramatic VIIRS data product improvements using MODIS data. This paper briefly reviews the key VIIRS design features that will lead to operational implementation of MODIS-demonstrated spectroradiometric advantages, as well as design features leading to dramatic imagery spatial resolution improvements. The paper provides illustrations of MODIS-derived applications, showing benefits of VIIRS over the current operational system using Navy pseudo operational product examples.

5658-02, Session 1

Equator crossing times for NOAA satellites

A. Ignatov, I. Laszlo, National Oceanic and Atmospheric Administration

The local Equator Crossing Times (EXT) of the National Oceanic and Atmospheric Administration (NOAA) platforms from TIROS-N and NOAA-o6 through -17 have been summarized as a function of time and approximated analytically. The fit equations (superposition of two harmonic terms, with platform-specific amplitudes, frequencies, and phases) accurately reconstruct all past EXTs to within ±2 min and also allow extrapolation in time, thus providing a useful insight into the phenomenology of its evolution. Fit equations are summarized in the paper, and used to predict the future EXT evolution. For instance, NOAA-16 will be flying at -1500 by 2006, -1600 by 2008, and -1800 by 2001. NOAA-17, after reaching its maximum EXT~io2o in 2005, will return to pre-launch value of 1000 by 2007, and subsequently decline to 0900 by 2009, and -0800 by 20011. This information is important for generation of the climate data records (CDR).

5658-03, Session 1

Science to operations: challenges, rewards, and pitfalls of converting and maintaining algorithm science code on-orbit

J. L. Duda, NASA Goddard Space Flight Ctr.; P. G. Emch, Northrop Grumman Corp.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) features remote sensing of the atmosphere, ocean, environment, and space. The NPOESS is the next generation of polar orbiting satellites that will provide measurements supporting weather, national security, and climate science. The NPOESS consists of a constellation of three satellites supported by attendant ground equipment used for the collection, analysis, and dissemination of measurements to government and civilian users. The purpose of the System is to collect global multispectral radiometry and other specialized meteorological, oceanographic, and solar-geophysical data and to disseminate these data to the system's central users and field users deployed worldwide.

The NGST/Raytheon Contractor Team selected to build and operate the system has responsibility for both hardware and algorithms. In 1997 the IPO created government science teams (comprised of scientists from government laboratories, universities, and non profit institutions). The initial role of these government Operational Algorithm Teams (OATs) was to oversee the development, documentation, and delivery of sound science code to the contractor. OATS included Sounding, Visible / Infrared Imagery and Radiometry, Microwave Imagery and Radiometry. The algorithms were documented via Algorithm Theoretical Basis Documents (ATBDs). Developmental sensors include ozone mapping and profiling (OMPS), cross track infrared sounder/advanced technology microwave sounder, CrIS/ATMS, visible/infrared imager radiometer suite, VIIRS, and conical microwave imager/sounder, CMIS. After success in achieving sound algorithm science code, this paper outlines how the science code is converted to operational code. Discussed are government/ contractor initiatives to develop a seamless process for science to operations. On-orbit challenges include maintaining sound science, configuration control, and implementing algorithm updates.

5658-04, Session 1

Development of an internally consistent calibration for 11AVHRR instruments in a 2o-year time series of satellite data

M. Schmidt, E. A. King, T. R. McVicar, CSIRO (Australia)

The AVHRR (Advanced Very High Resolution Radiometer) data record comprises the longest existing daily remote sensing dataset. The CSIRO AVHRR time series, includes data from alt of the NOAA polar orbiters since NOAA-6 in 1981 through NOAA-17 today for Australasia. Both inter- and intrasatellite factors affect the usability of these data for the generation of consistent time series of meteorological and geo/bio-physical parameters. Not only do the particular AVHRR instruments on the individual satellites differ in terms of spectral response and sensitivity, but the sensitivity varies with time, and the evolution of each satellite's orbit results in changes in target illumination and viewing geometry that must be taken into account.

To improve our knowledge of the of the measurement variation of the different AVHRR instruments we have applied various method. These methods include the use of high tropical clouds, multivariate alternate detection, pseudo-invariant features and co-eval bi-directional reflectance distribution functions. A comparison of the operability and effectiveness of these methods is provided and their relative impact on the overall consistency and long term calibration of the time series is described.

5658-05, Session 1

Calibration of the solar reflective channels in an integrated, operational weather satellite system in the era of NPOESS and GOES-R

J. C. Bremer, J. C. Criscione, M. S. Maxwell, T. R. Pedersen, Swales Aerospace

The operational imaging instrument on the NPOESS satellites will be the Visual/Infrared Imager/Radiometer Suite (VIIRS). The operational imaging instrument on the GOES-R satellites will be the Advanced Baseline Imager (ABI). The VIIRS is presently planned to have a total of 13 solar reflective spectral bands, with central wavelengths ranging from 4i2nm to 225onm. The ABI is presently planned to have a total of 6 solar reflective spectral bands, with central wavelengths ranging from 47onm to 226onm. Some of the ABI's spectral bands are similar, but not identical to, those of the VIIRS.

Each VIIRS instrument will be equipped with a diffuser plate for on-board, end-to-end calibration of its reflective channels. The ABI is currently planned to have on-board, full-aperture, end-to-end calibration of its reflective channels. Another calibration alternative is to compare the value of the Earth's full-disk irradiance in each reflective channel as derived from the ABI with the value derived from a matched spectral channel in a small, non-imaging radiometer that simultaneously measures the ratio of the full-disk irradiance to that of the Sun.

It has been proposed that the specifications for the ABI's spectral bands be changed to match similar bands of the VIIRS, to facilitate the cross-calibration of these instruments and the merger of data from multiple platforms into fused data products. The objective of this study is to characterize the errors in cross-calibration due to variations in nominally equivalent spectral bands on different instruments and due to nearly simultaneous co-observations of the moon and of terrestrial targets along very similar lines-of-sight.

5658-07, Session 1

An alternative approach to the channel selection problem for the infrared multi-channel spectral data with using hypothetical channel system

T. Aoki, National Institute for Environmental Studies Oapan)

A method has recently been shown by Aoki (2004) to compress the number of channels of trace gas remote sounder preserving almost all the information content that the original data has. It has been shown that the radiance data of 240 of original channels in the near infrared region can be compressed to 5 or less channels of hypothetical radiances with loosing negligible information content.

In the present paper, the performance of this method is examined for the simulated radiance data of high spectral resolution in the thermal infrared region that is used for the remote measurements of temperature and humidity vertical profiles. The number of hypothetical channels that is required for preserving the information content of original data has been examined. The present study showed that the radiance data of 1200 channels of high spectral resolution o.i cm-i is compressed to less than 23 hypothetical channels with negligible loss of information content in the case of wave number region 640-760 cm-i, which is used for the temperature soundings. In the case of the humidity sounding from the region 1300-1600 cm-i with the spectral resolution o.i cm-i, 3000 channels are compressed to less than 20 of hypothetical channels.

5658-08, Session 1

Vertical resolution study on the GOES-R Hyperspectral Environmental Suite (HES)

J. Li, F. Wang, Univ. of Wisconsin/Madison; T. J. Schmit, W. P. Menzel, j. j. Gurka, National Oceanic and Atmospheric Administration

High spectral resolution infrared radiances from the Hyperspectral Environmental Suite (HES) on Geostationary Operational Environmental Satellite (GOES-R and beyond) will allow for monitoring the evolution of atmospheric temperature and moisture vertical distributions. HES, together with the Advanced Baseline Imager (ABI), will operationally provide enhanced spatial, temporal and vertical information for radiances and atmospheric soundings that are desired by numerical weather forecast models. An algorithm has been developed to analyze the retrieval error and the vertical resolution of soundings from HES radiances. Trade-off studies have been done to balance the spectral coverage, spectral resolution, and signal-to-noise ratio in order to achieve the GOES users' requirement of iK accuracy with ikm vertical resolution for temperature and 10% accuracy with 2km vertical resofution for relative humidity. The vertical resolution capability of HES is also compared with that of the current GOES Sounder which has 18 infrared spectral channels and the Advanced Microwave Sounding Unit (AMSU) on the NOAA polar orbiting satellites that has good temperature sensitivity in the lower stratosphere and upper troposphere. The advantage of combination of GOES sounder and AMSU is also investigated.

5658-09, Session 1

Risk reduction activities for future GOES-R instrumentation

D. W. Hillger, M. DeMaria, National Oceanic and Atmospheric Administration and Colorado State Univ.; J. F. W. Purdom, Colorado State Univ.; C. D. Barnet, National Oceanic and Atmospheric Administration

An extensive program is underway to simulate imagery and sounder data from future GOES-R instrumentation. The goal is to assess the potential for newproducts from GOES-R long before it becomes operational. Simulations of GOES-R data are being accomplished by utilizing datasets from current operational and experimental satellites. Weather situations under study include applications to forecasting mesoscale weather events, including severe storms, tropical cyclones, lake effect snowstorms and fog outbreaks. The simulations are needed to assess the impact of the increased resolutions available from GOES-R instrumentation. Increases in spatial, temporal, spectral, and radiometric resolution will all be available, the latter two being manifest as both increased number of spectral bands and increased precision for measurements from those bands. One of the approaches being used for these "Risk Reduction" activities is to use data from existing operational and experimental satellites to create subsets of observations that will be available from GOES-R. Then an assessment of the potential applications of these GOES-R data will be made using techniques to manipulate both the multi-spectral imagery and the hyper-spectral sounding data. The image manipulation techniques that will be applied not only pare the data down to its essential components, eliminating redundant information, but also assess the quality and applicability of the data to the weather situations under study. Another approach will be the assessment of the soundings that will be available from the hyperspectral sounder on GOES-R. For this purpose, infrared temperature and moisture retrievals from the hyperspectral Atmospheric InfraRed Sounder (AIRS) are being evaluated in the environments of tropical cyclones and severe thunderstorms by comparison with in situ measurements.

5658-10, Session 2

Japanese advanced meteorological imager

). J. Puschell, Raytheon Space and Airborne Systems

The Japanese Advanced Meteorological Imager (JAMI) was developed by Raytheon and delivered to Space Systems/Loral as the Imager Subsystem for Japan's MTSAT-iR satellite, which is scheduled for launch in late 2004. Due to Japan's urgent need to replace MTSAT-i, which was destroyed in a launch failure in 1999, JAMI was developed on an expeditious 39-month schedule. Raytheon's success in respondingto the needs of MTSAT-iR and delivering an excellent operational geosynchronous Earth orbit (GEO) imager was enabled by an elegant instrument architecture and use of newer but proven technology that simplified design, assembly and test of the Imager while simultaneously supplying superior performance. A dedicated and talented management and test team characterized performance of this innovative, advanced technology design with unmatched efficiency and found that (AMI meets all MTSAT-iR requirements with margin. JAMI breaks through limitations of earlier three-axis stabilized GEO instruments with significant improvements in many areas, including spatial sampling, radiometric sensitivity, calibration and performance around local midnight.

5658-12, Session 2

Design and Analysis of a Beryllium Three-Mirror Anastigmat Telescope for the Japanese Advanced Meteorological Imager (JAMI)

J. L. Bell, Jr., M. Pavlov, Raytheon Santa Barbara Remote Sensing

Raytheon's Santa Barbara Remote Sensing facility in Goleta, California designed and built an advanced meteorological imager for the Japanese Ministry of Transport between March, 1999 and July, 2002 for MTSAT-iR. One of the most stressing requirements is visible band image quality near local midnight. Through careful thermal, structural, and optical (STOP) analysis, the design team was able to optimize the designs of the telescope and thermal control system while meeting the challenging procurement schedule forthe telescope.

5658-13, Session 2

Telescope performance near local midnight for the Japanese Advanced Meteorological Imager (JAMI)

M. M. Pavlov, J. L. Bell, Jr., M. Jacoby, B. Shreckengost, Raytheon Santa Barbara Remote Sensing

Raytheon's Santa Barbara Remote Sensing facility in Goleta, California designed and built an advanced meteorological imager for the Japanese Ministry of Transport between March, 1999 and July, 2002 for MTSAT-iR. As a result of the interactive process implemented, the design forthe beryllium three-mirror anastigmat (TMA) telescope was evaluated via structural, thermal, and optical (STOP) analysis for the simulated on-orbit conditions. Consequently the telescope was optimized for minimum distortion around local midnight. On-orbit temperatures and structural deformations were predicted using thermal Desktop/SINDA and PATRAN/NASTRAN software, respectively. The resulting optical performance was evaluated using Raytheon HEXAGON. The telescope design was successfully optimized to attain specified visible channel performance very close to local midnight.

5658-14, Session 3

Nowcasting severe weather with GOES-R

J. F. W. Purdom, Colorado State Univ.

The United States of America's future geostationary satellite series, GOES-R, is expected to be a geostationary constellation whose major meteorological observing instruments are an Advanced Baseline Imager (ABI) with up to 16 channels, and a Hyperspectral Environmental Suite (HES) that is comprised of a hyperspectral imager operating in the 0.4 to i micron range (HES-VNIR) and an atmospheric sounder operating across the 4-15 micron portion of the spectrum (HES-IR). Nowcasting convection may be thought of as a three tiered process: i) assessment of the precursor storm environment; 2) the initial phases of storm development; and, 3) the development and evolution of deep convection. Each of the major meteorological instruments on GOES-R has a valuable role to play during all of the nowcast phases. With GOES-R, all three instruments will be used in synergy to precisely define the evolving thermo-dynamic and kinematic fields that support ordinary and severe storm development and evolution. The use of multi-channel imagers and sounding interferometers are well recognized for value to analyze a variety of atmospheric and surface phenomena. Based on experience from current generations of geostationary satellites, rapid interval imagery updates have proven valuable for nowcasting, cloud motion vector determination and providing opportunities for cloud free fields of view for surface related product generation. The multi-spectral nature of ABI will greatly add to this assessment capability in a number of areas: routine 5 minute interval imagery with super rapid scanning capability; very accurate cloud motions and cloud heights; multispectral analysis of cloud top behavior yielding clues of updrafttype and intensity; and very accurate surface heating rates. The hyperspectral HES will provide detailed information such as atmospheric moisture, thermodynamic instability, storm/ environment interaction, and the formation and decay of low-level thermal inversions. As valuable as ABI and HES information are, the high spatial and temporal resolution visible to near infrared hyperspectral imager (HES-VNIR), when used in synergy with ABI and HES, promises to revolutionize geostationary satellite applications for nowcasting. While hyperspectral VIS-NIR has historically focused on land and ocean applications, it can provide exceptionally valuable information for atmospheric related applications. For example, hyperspectral information in the 0.4 to i micron band can be used for applications that rely on scattering such as haze, smoke, dust and aerosols, studies of cloud (especially in conjunction with an ABI), and very importantly determination of column water vapor over land. This paper will address how the instrument suite can be used to determine very high-resolution information about water vapor, pinpoint areas of greatest destabilization, monitor areas with increased moisture convergence and predict where the strongest thunderstorms will develop. In addition, we will measure cloud motion precisely, determine vertical shear in the cumulus layer and measure boundary layer destabilization. As storms mature we will monitor storm growth rate and the effect of environmental shear on storm development. When the storm becomes mature, through monitoring energy input at base and overshooting top height we will be able to identify storms that are most efficiently usingCAPE. Through determinations of this type we will be able to provide exceptionally accurate 0-6 hour nowcasts of severe storm potential, development, character and evolution.

5658-15, Session 3

The satellite-derived hydro-eslimator and hydro-nowcaster for mesoscale convective systems and landfalling tropical systems

R. A. Scofield, R. J. Kuligowski, National Oceanic and Atmospheric Administration

For over 20 years, the Satellite Analysis Branch (SAB) of the National Environmental Satellite, Data, and Information Service (NESDIS) has provided satellite-derived quantitative precipitation estimates (QPE's) and trend / short-term forecast information for heavy rain in order to assist field forecasters in identifying and predicting flash flooding. However, until approximately 5 years ago the production of satellite QPE's had a significant manual component, limiting both its available coverage and its timeliness, and preventing its impact on flash flood forecasting from reaching its full potential. In response, scientists at NESDIS developed an automated algorithm for estimating precipitation called the Auto-Estimator (A-E), which provided real-time estimates over the continental United States and surrounding regions with a latency time of just minutes. The A-E and its successor, the Hydro-Estimator (H-E), have significantly increased the usefulness of satellite QPE's in flash flood forecasting in the United States. In addition, experimental H-E products are now being produced using all five geostationary satellites in the Global Observing System (GOS) and are made available via the Internet to any interested users at http://www.orbit.nesdis.noaa.gov/smcd/emcb/ff/index.html.

However, guidance on satellite trends and short-range forecasts, which provide additional lead time in flash flood forecasting situations, must still be produced manually; thus, their availability and timeliness remain limited just as that of satellite QPE's had been until recently. To fully exploit the potential of this information, an automated nowcasting algorithm called the Hydro-Nowcaster (H-N) has been developed. The H-N computes speed and direction vectors for each Meso-Beta Core (MBC) based on consecutive images, and uses this information to extrapolate the H-E precipitation fields forward in time for up to 3 hours. Information on time changes in size and temperature of the precipitation cores are used to infer continued growth or decay for each MBC. This technique is also applied to landfalling tropical systems in the Tropical Rainfall Nowcaster (TRaN).

The H-E and H-N are undergoing re-calibration in order to improve the performance of both algorithms. The impacts of this recatibration wilt be presented, along with examples of worldwide application that is planned for the H-N (as is now done for the H-E), which would greatly benefit regions where radar and raingauge data are unavailable or unsuitable for economic or other reasons.

5658-16, Session 3

A nowcasting tool for the evolution of convective cells using the water vapor absorption and infrared window channels of the Meteosat second generation.

S. Puca, EUMETSAT (Germany) and Italian Air Force Met Service (Italy); L De Leonibus, F. Zauli, P. Rosci, L Musmanno, D. Biron, Italian Air Force Met Service (Italy)

At the Italian Meteorological Institute a neural network model (NN) was defined in order to forecast the convective systems evolution in the Mediterranean area. This model, composed by a system of neural networks, uses combination of water vapour absorption (WV) and infrared window (IR) data of Meteosat Second Generation (MSG). For forecasting evolution of convective systems we realized that cloud top temperature, from IR window channel, does not give enough predictor information. As consequence of that we introduced information about middle troposphere cloud basic elements, as humidity, from water vapor absorption band. We had preliminary results using the Meteosat rapid scan (RS) data. The use of WV and IR data from Meteosat-6 RS service, with a time sampling of 10 minutes, allowed us to track satisfactory the evolution of convective cells and it improved the detection of the beginning of the life cell. We can say that information of IR channel temperature only is not
enough, for example, to evaluate the dissolving phase of the convective celt. A small decrease of the temperature of the cloud top (detected in the IR channel) it is not a unique indication for the beginning of this phase. It is known that, during mature phase, a convective cell may have a pulsating behaviour, so its top increases and decreases for an unknown time interval.

After having defined three main evolution phases on the base of the features deduced from IR and WV channels, a specific NN algorithm was set up for nowcasting convective cells, using MSG data. A statistical analysis of cross-correlation between time series of different channels was performed for different areas of the Mediterranean region. From these statistics we may conclude that the performance of the NN system is more than satisfactory. This allows us to improve the operational automatic nowcasting application with the insertion of a NN module which gives information on the evolution of convective systems. In this way the forecasters are able to evaluate the probability of a severe increase or decrease of the convective activity.

5658-17, Session 3

Dark area of satellite vapor imagery and heavy convective systems

B. Fu, W. Chen, Nanjing Institute of Meteorology (China)

One of the greatest challenges of an operational meteorologist is predicting the occurring time the intensity of the heavy convective systems. In this paper, we applied the dark area moving of satellite vapor imagery on the heavy convective systems early warning. The dark area in vapor imagery represents the range of dry and dry cold air, all the convective weather events needs the joining of cold air, so the moving of dark area of vapor imagery can be used to determine the location of heavy convective systems. Generally we consider that there are two types of cold air path leading to the development of convective systems, one is northern, and the other is western. For the northern path, we determined the key area, 4O-45N, no-i2oE, for the western path, we selected the key area, 35-4oN, loo-noE. If the forecasting location is becoming very instability, the dark area of vapor imagery approach the key area and there is the generation of cell cloud round the forecasting location, then 3 hours later, Mesoscale convective systems (MCS) will occur in this location. MCSs may be accompanied with thunderstorm, heavy gust and hail.

5658-18, Session 4

The impact of current and future polar orbiting satellite data on numerical weather prediction at NASA/GSFC

R. M. Atlas, NASA Goddard Space Flight Ctr.

The lack of adequate observational data continues to be recognized as a major factor limiting both atmospheric research and numerical prediction on a variety of temporal and spatial scales. Since the advent of meteorological satellites in the 1960*5, a considerable research effort has been directed toward the design of space-borne meteorological sensors, the development of optimal methods for the utilization of these data, and an assessment of the influence of existing satellite data and the potential influence d? future satellite observations on numerical weather prediction. This has included both Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs). OSEs are conducted to evaluate the impact of specific observations or classes of observations on analyses and forecasts. While OSEs are performed with existing data, OSSEs are conducted to evaluate the potential for future observing systems to

improve NWP, as well as to evaluate trade-offs in observing system design, and to develop and test improved methods for data assimilation. At the conference, results from OSEs to evaluate satellite data sets that have recently become available to the global observing system, such as AIRS and SeaWinds, and results from OSSEs to determine the potential impact of space-based lidar winds will be presented

5658-19, Session 4

The joint center for satellite data assimilation: status and future

J. F. Le Marshall, Jackson County Sanitary Disposal Agency

The Joint Center for Satellite Data Assimilation (JCSDA) was established by NOAA, NASA and DoD in 2002. The goal of the JCSDA is to accelerate the use of observations from earth-orbiting satellites in operational numerical prediction models for the purpose of improving weather forecasts, improving seasonal to interannual climate forecasts, and increasing the accuracy of climate data sets. Advanced instruments of current and planned NOAA, NASA, DoD, and international agency satellite missions, increasingly provide large volumes of data on atmospheric, oceanic, and land surface state with accuracies and spatial, spectral and temporal resolutions never before achieved. The JCSDA will ensure that the maximum benefit from this investment in space is realized. To this end, the advancement of data assimilation science by the JCSDA has included preparation for use of data from the METOP, IASI/AMSU/ HSB instruments and the DMSPSSM/IS, real-time delivery of EOS-AquaAMSR-E to NWP centers, the unification of the NCEP global data assimilation analysis system and the equivalent NASA Global Modeling and Assimilation Office (GMAO) system, the upgrade of the JCSDA community-based radiative transfer model for AIRS and the incorporation of snow and sea ice emissivity models for improving the use of microwave sounding data over high latitudes. Twenty one other research projects are also being supported by the JCSDA (e.g. use of cloudy radiances from advanced satellite instruments) to develop a state of-the-art satellite data assimilation system. The development work undertaken by the JCSDA will be summarized at this meeting.

5658-20, Session 4

Assimilation of AMSU-A/B radiances with the NRL Atmospheric Variational Data Assimilation System (NAVDAS)

N. L Baker, C. B. Blankenship, W. F. Campbell, Naval Research Lab.; S. Swadley, METOC Consulting; T. Hogan, E. Barker, Naval Research Lab.

The U.S. Navy's new three-dimensional variational analysis system NAVDAS became operational at Fleet Numerical Meteorology and Oceanography Center (FNMOC) on October i, 2003, and paves the way for the direct assimilation of satellite radiances. This presentation describes the procedures used for AMSU assimilation and presents the assimilation results.

NAVDAS assimilation of NOAA AMSU-A radiances with the Navy Operational Global Atmospheric Prediction System (NOGAPS) leads to significant improvement in forecast skill, as compared with assimilation of NESDIS ATOVS retrievals. The two- to five-day forecast skill at 500 hPa is increased by 3-10 hours in the Northern Hemisphere, and by 12-20 hrs in the Southern Hemisphere, with simitar improvements at 1000 hPa. Forecasts with AMSU-A are consistently better, with fewer forecast "busts", fewer synoptic errors and a general strengthening of the circulations in both hemispheres. Overall, NAVDAS analyses and forecasts with AMSU-A exhibit better fit with radiosondes and other observations. The AMSU-A assimilation is currently being transitioned to FNMOC with an anticipated implementation date of May 2004.

NRL is also developing the assimilation of AMSU-B radiances. AMSU-B is sensitive to the vertical distribution of water vapor in the troposphere. iDVAR retrievals of humidity profiles are calculated from AMSU-B observations and a NOGAPS background, and assimilated into NOGAPS using NAVDAS.

The accuracy of the water vapor retrievals were validated by comparing GOES imager 6.7 (im observations with synthetic radiances generated from the retrieved water vapor profiles. Simulated GOES Tbs were correlated with observed Tbs at r=o.90 and an rms error of 2.9K.

Assimilation of AMSU-B retrievals dries out the middle and upper troposphere, and strengthens moisture gradients over the Intertropical Convergence Zone, correcting known model tendencies. Tropical cyclone track and intensity predictions are slightly improved. Transition of AMSU-B retrieval assimilation to operations at FNMOC is targeted for the fall of 2004.

5658-21, Session 4

Weather and climate research with AIRS/AMSU

J. Susskind, NASA Goddard Space Flight Ctr.

AIRS was launched on EOS Aqua on May 4, 2002, together with AMSU A and HSB, to form a next generation polar orbiting infra-red and microwave atmospheric sounding system. AIRS/AMSU/HSB products are important for both weather and climate applications. The primary products of AIRS/AMSU/HSB are twice daily global fields of atmospheric temperature-humidity profiles, ozone profiles, sea/land surface skin temperature, and cloud parameters including OLR. The sounding goals of AIRS are to produce i km layer mean tropospheric temperature with an RMS error of iK, and i km layer precipitable water with an RMS error of 20%, in cases with up to 80% fractional cloud cover. Sample fields of products derived from AIRS/AMSU/HSB will be presented and temperatures will be validated as a function of retrieved cloud cover. Data for the months of January 2003 and 2004 were analyzed. Results will be shown with regard to improvement of forecast skill and the study of interannuat differences using AIRS soundings.

5658-22, Session 4

Uses of satellite microwave measurements to improve hurricane prediction

F. Weng, National Oceanic and Atmospheric Administration

Tropical cyclones develop over the vast ocean, where few convectional observations are available. This lack of observation is one of the major factors affecting the accurate prediction of tropical storms. To predict reasonably the track and intensity of hurricanes using numerical models, one has to bogus into the model initial conditions a vortex at the right location with realistic intensity since in most cases operational analyses contain a vortex that is often too weak and may have it misplaced. In this study, we assimilate advanced satellite data from EOS Aqua sensors (AMSU-A/AMSR-E) into NCEP global forecast model outputs to produce an analysis in characterizing a hurricane vortex. This vortex is embraced with three-dimensional atmospheric temperature, wind, mixing ratios of water vapor, cloud, rain,

and ice water, as well as two-dimensional surface wind and sea surface temperature. The information on atmospheric temperature and wind is derived primarily from AMSU-A which is a microwave sounding instrument having 13 channels near 50-60 GHz oxygen absorption line, where the surface products are obtained from AMSR-E which is microwave imaging instrument having 12 channels from 6.9 to 89 GHz. The measurements from both AMSU-A and AMSR-E are integrated to derive various mixing ratio profiles associated with clouds and precipitation.

The effectiveness of observationally derived hurricane vortex as the model initial conditions is tested using 48-h simulations of Hurricane Isabel with the finest grid size of the 4 km Weather Research and Forecast (WRF) model. It is found that without the incorporation of the satellite data, the simulated intensity and cloud structures differ markedly from the observed.

5658-40, Session 4

Status and outlook of very short-range forecasting system in central weather bureau: Taiwan

P. T. Chiou, C. Chen, P. Chang, G. Jian, Central Weather Bureau (Taiwan)

The operational Very Short-Range Forecasting System (VSRFS) in Central Weather Bureau (CWB) has being under progressive development in CWB since 2002. One component of the VSRFS is the Quantitative Precipitation Estimation-Segregation Using Multiple Sensors (QPESUMS) under a joint development program between NSSL/NOAA and CWB (Gourley et al. 2002 J. Hydrom-eteor). In QPESUMS, the Doppler radar, satellite infrared, raingauge data and others are used to make QPE for severe weather systems in Taiwan. Products from QPESUMS are presented in web page format. Currently, it shows that the QPE from QPESUMS has a good agreement with the surface observation when precipitation rate is greater than icmm/hr. Efforts are put to the improvement of QPESUMS for making reasonable o-2hr QPF (forecast) by the end of 2005.

Another component of the VSRFS is a diabatically initialized LAPS (local analysis and prediction system) PSU/NCAR MMs system under a joint development program between FSL/NOAA and CWB for 2-i2hr QPF. LAPS-MMs is designed to effectively shorten the spin-up problem of simulating convective storms Can et al., 2003; TAO). Various data sources are assimilated into LAPS for MMs to make time integration. The uniqueness of hot-start MM; lies in the (i) cloud analysis, which is designed to provide the model with a three-dimensional description of the hydrometers in the atmosphere, (2) dynamic balance scheme, which is to ensure that the momentum and mass fields are consistent with the cloud-derived vertical motions. It turns out that LAPS-MMs is capable to predict the strength and location of heavy precipitation system with 6-hourly rain rate greater than 35mm (higher Equitable Threat Score), yet prone to over-predict the rainfall rate when precipitating system was weaker. In order to suit the need for near real-time (2-i2hr) severe weather forecast, many challenging tasks related to the cloud/moisture analysis, dynamic/ther-modynamic balance schemes are to be overtaken in the forthcoming years.

5658-23, Session 5

A new AVHRR cloud climatology

A. K. Heidinger, M. D. Goldberg, National Oceanic and Atmospheric Administration

NOAA/NESDIS has recently funded a new reprocessing of the entire AVHRR data record. The work has included research in techniques to improve in the thermal and visible calibration and in the pixel level navigation. One application of this improved AVHRR data is a new version of the extended AVHRR Pathfinder Atmospheres (PATMOS-x) data-set. This data set differs from the previous in that it includes data from the morning and afternoon satellites and includes the NOAA-klm data. This presentation will give preliminary results of the recent processing. The results will include a comparison of the observed trends in the cloud properties compared to other satellite derived climatologies.

5658-24, Session 5

Global diagnostics of operational AVHRR SST and aerosol retrievals from NOAA-16 and NOAA-17

A. Ignatov, J. Sapper, W. G. Pichel, E. Maturi, National Oceanic and Atmospheric Administration; A. I. Harris, Univ. of Maryland/College Park; A. Strong, E. J. Bayler, I. Laszlo, National Oceanic and Atmospheric Administration; N. R. Nalli, QSS Group, Inc.

Under cloud-free conditions during the daytime, global synergetic retrievals of sea surface temperature (SST) and aerosol optical depths (AOD) are made from AVHRR instrument flown onboard polar-orbiting quasi sun-synchronous NOAA-16 (equator crossingtime, EXT~i4oo) and -17 (EXT~iooo) satellites. The daytime SST is derived using a non-linear split-window technique from the two Earth emission bands (EEB) centered at n and 12 :m. Three AODs are retrieved in the solar reflectance bands (SRB) centered at 0.63,0.83, and 1.61 :m. In this paper, the previously documented physics and retrieval algorithms are only briefly described. The main emphasis is on diagnostics of the SST and aerosol products using a number of previously developed self- and inter-consistency checks that are global and statistical in their nature.

The NOAA-16 and -17 SSTs for one week in December 2003 have been first converted to anomalies, by subtracting the climatological SST, and then aggregated into i-day, i-degree boxes, and the global statistics of the resulting anomalies examined. Histograms of NOAA-i6 and -17 anomalies agree closely, both showing an approximately Gaussian shape, with a mean of ~+o.iK and RMS~iK. The NOAA-16 and -17 anomalies are highly correlated (R~o.8), with RMS difference between the two platforms to be on order of ~o.7K. Assuming that the errors in the two SST products are comparable, this gives an estimate of the SST RMS error-o.sK.

AODs from NOAA-16 and -17 show much similarity (correlation coefficient from R~o.7-o.8, in three bands), but reveal significant cross-platform biases. The magnitudes and even the signs of these biases are band-specific, suggesting that they are due to calibration differences between the two AVHRRs flown on the two platforms. Recall that the AVHRR solar reflectance bands are not calibrated in orbit, and therefore are subject to large calibration errors. These SST and aerosol results are further discussed in the paper.

5658-25, Session 5

Observation of dust haze over Asian tropical regions from operational GOES-9 imagery

T. K. Jong, Natural Resources and Environment Board (Malaysia) and Lexical Technology Re Ltd (Singapore); Y. G. Zhang, Lexical Technology Re Ltd. (Singapore)

Natural Resources and Environment Board (NREB) of Sarawak has embarked on a Joint Pilot Project with local and oversea company namely Hycare Sdn Bhd in collaboration with Ellipsiz and Lexical Technology Singapore Pte Ltd to restore the functionality of Geostationary Satellite data reception from GOES-9 following the GMS. A GOES-9 satellite data reception and processing system was put into operations since October 2003.

The primary purpose was to monitor Haze and Hot Spots arising from fire. These operational needs have been met to the satisfaction of the Users. In Mar 2004, Haze was observed in the Sarawak state without a correspondingly increase in the number of hot spot detected. The members of public were concerned and the relevant authorities need to determine the root cause.

Based on the visual interpretation of the imageries generated from GOES-9 data, coupled with other complimentary sources of relevant data such as PSI value, visibility value and hot spot counts compiled over the same period, NREB is of the opinion that the haziness was caused by the sandstorm originating from China.

This is the first time where the South East Asian region in general, and Sarawak, in particular, has been affected by sandstorm fallout from China. NREB seeks to share such imageries and information leading to such a beneficial observation of this unusual environmental phenomenon. A Case Study by NREB to show how GOES-9 satellite data can be processed to account for the haziness of Sarawak State in Mar 2004.

The data could be further substantiated if there were MODIS data collected from the 0.4 to o.6-(xm channels. A Case Study by NREB to show how GOES-9 satellite data can be processed to account for the haziness of Sarawak State in Mar 2004. The significance of this paper lies in the fact that NREB could determine and explain to members of public the root cause leading to the haze situation. This is an added beneficial application of the GOES-9 system. This also further justified for the returns on Investment for this GOES-9 system.

5658-28, Session 5

Providing realistic vegetation phenological description for regional climate simulations

L. Lu, Colorado State Univ.

A climate version of the Regional Atmospheric Modeling System (ClirnRAMS) is used to simulate vegetation-atmosphere interactions in the Great Plains and Rocky Mountain regions of the United States. The NDVI is assumed to provide a remotely sensed measure of the evolution of vegetation phenology and NDVI-derived LAIs are directly assimilated into the ClirnRAMS simulations. Two kinds of model integrations have been performed, one with and one without assimilating the observed vegetation distribution. Differences between the model runs are used to highlight model deficiencies and limitations, and to identify areas of possible improvement in the atmospheric model. The results show that seasonal and interannuat vegetaion phonological variation strongly influences regional climate patterns via its control of land-surface water and energy exchange. The need to realistically represent vegetation evolution in the regional climate model is thus identified, and is addressed by coupling the CENTURY ecological model with ClimRAMS to account for vegetation growth. The resulting coupled model captures key aspects of weekly, seasonal, and annual feedbacks between the atmopsphere and ecological systems.

5658-29, Session 5

Study on cloud property retrieval with MODISIR spectral bands

H. Zhang, J. Li, Univ. of Wisconsin/Madison; W. P. Menzel, National Oceanic and Atmospheric Administration and Univ. of Wisconsin/ Madison

The operational MODIS products for cloud properties such as cloud-top pressure (CTP), effective cloud emissivity (ECA), cloud particle radius (CPR), cloud optical thickness (COT), and cloud phase (CP) have been available for users globally. An approach to retrieve cloud COT and CPR is investigated using MODIS infrared (IR) spectral bands (8.5 mm, iimm, 12 mm and 13.3 mm). The COT and CPR retrievals from MODIS IR bands have the potential to provide complement any microphysical properties with high spatial resolution during night. The results are compared with those from operational MODIS products derived from the visible and near-infrared bands during day, as well as the retrievals from high spectral resolution Atmospheric Infrared Sounder (AIRS) measurements.

Sensitivity of COT and CPR to MODIS spectral brightness temperature (BT) and 6T difference (BTD) values is studied. A look-up table is created from the cloudy radiative transfer model accounting for the cloud absorption and scattering for the cloud microphysical property retrieval. The potential applications and limitations are also discussed. This algorithm can be applied to the future imager systems such as VIIRS on NPOESS and Advanced Baseline Im-ager(ABI)onGOES-R.

附錄 2:中央氣象局極短時預報系統現況及未來發展論文
Status and Outlook of Very Short-Range Forecasting System in Central Weather Bureau, Taiwan

Paul Tai-Kuang Chiou*, Chia-Rong Chen, Pao-Liang Chang, Guo-Ji Jian
Meteorological Satellite Center, Central Weather Bureau,
64 Kung-Yuan Road, Taipei, Taiwan 10039

ABSTRACT

The main purpose of Very Short-Range Forecasting System (VSRFS) is to develop algorithms for real-time monitoring and forecasting severe weather systems, which may result in flood, flash flood or landslide in Taiwan area. The operational VSRFS has being under progressive development in CWB since 2002. One component of the VSRFS is the QPESUMS system which is under a joint development program between US NOAA/NSSL and CWB. In QPESUMS, the Doppler radar, satellite infrared, raingauge and other data sources are ingested to make QPE for severe weather systems in Taiwan. Products from QPESUMS are presented in web page format. Currently, it shows that the QPE from QPESUMS has a good agreement with the surface observation when precipitation rate is greater than 10mm/hr. Efforts are put to the improvement of QPESUMS for making reasonable 0-2hr QPF by the end of 2005. Another component of the VSRFS is a diabatically initialized LAPS-MM5 system which is under a joint development program between NOAA/FSL and CWB for 2-12hr QPF. LAPS-MM5 is designed to effectively shorten the spin-up problem of simulating convective storms. Various data sources are assimilated into LAPS for MM5 to make time integration. It turns out that LAPS-MM5 is capable to predict the strength and location of heavy precipitation system with 6-hourly rain rate greater than 35mm (higher Equitable Threat Score), yet prone to over-predict the rainfall rate when precipitating system was weaker. In order to suit the need for near real-time (2-12hr) severe weather forecast, many challenging tasks related to the cloud/moisture analysis, dynamic/thermodynamic balance schemes are to be overtaken in the forthcoming years.

Key Words: VSRFS, QPESUMS, LAPS-MM5

1. INTRODUCTION

The Very Short-Range Forecasting System (VSRFS) under the Climate Variation, Severe Weather Monitoring, and Forecasting System Development Project in Central Weather Bureau (CWB) has being under progressive development in CWB since 2002. The main purpose of VSRFS is to develop algorithms for real-time monitoring and forecasting severe weather systems, which may result in flood, flash flood or landslide in Taiwan area. It is anticipated that the VSRFS will be able make reasonable 0 to 12 hours quantitative precipitation forecast (QPF) on these short-lived but life-threatening systems. Continuing efforts have been put to two major components of the VSRFS. The first sub-system is the Quantitative Precipitation Estimation-Segregation Using Multiple Sensors (QPESUMS) system, which is designed to be able to make real-time QPE and ultimately 0-2hr QPF on severe weather events. The second one is the diabatically initialized LAPS (local analysis and prediction system) and Penn State University/National Center for Atmospheric Research Mesoscale Model version 5 (PSU/NCAR MM5) system, which is designed to be capable of mitigating the well-known spin-up problem of numerical models and of making the 2-12hr QPF on the severe weather systems.

2. QPESUMS SYSTEM

* paul@msc.cwb.gov.tw; phone 886-2-2349-1235; fax 886-2-2349-1259

The QPESUMS system is under a joint development program between NSSL and CWB (Gourley et al. 2002; Chiou et al. 2004). It utilizes a multi-sensor approach to generate improved QPE and subsequently the identification of atmospheric conditions leading to flash floods and etc. The QPESUMS algorithms are able to provide better estimates of precipitation types (convective, stratiform or tropical) and rates (using adaptive Z/r-s regression) using an optimal blend of radar, satellite, gauge rainfall and environmental data that are scientifically and physically based. The QPEs made by the QPESUMS are under further refinement and nudging on river basins level by integration of rain and river

gauge data when and where available.All data ingested in QPESUMS are mosaicked to a common grid providing a "one-stop" radar analysis tool. Below is a simplified outline of QPESUMS.

- Ingest data (radar, Rapid Update Cycle (RUC-II), satellite, surface, lightning, upper-air)
- Create precipitation rate and type flags for each radar
- Re-map and mosaic polar data from each radar to a common grid
- Produce quantitative precipitation estimates

The following steps are done in polar coordinates:

- Ingest data
- Perform quality control (e.g., Anonymous Propagation (AP) removal, noise filter)
- Determine precipitation character (e.g., convective vs. stratiform)
- Search for a bright band and return top and bottom heights
- Determine if radar is sampling rain or snow (determines Z-R/S)
- Use LAPS and beam heights to determine good/bad rain/snow
- Compute precipitation rates using appropriate Z-R/S
- Output precipitation rates and 5 flags: convective, good/bad rain/snow

The following steps involve the full domain Cartesian grid:

- Re-map and mosaic polar products to common grid
- LAPS gridded 0℃ heights to modify good/bad rain/snow coverage
- Satellite and surface data are used to eliminated false echo in clear air
- If available, lighting is used to identify convection
- Radar-only water-equivalent fields are created
- IR satellite-only water-equivalent fields are created
- Multi-sensor water-equivalent fields are created
- Above products are adjusted by gauges

The initial QPESUMS system was operational in late 2002 and has been under functional improvements. In QPESUMS, the mosaic from Doppler Radars (reflectivity and radial wind) and other data sources (Fig. 1) is used to identify and track individual storm cell and storm systems (Fig. 2). The QPE's associated with these cells and systems are then made with a ten-minute update cycle. The QPE is adjusted by the real-time raingauge data (Fig. 3).

To enhance the usefulness of QPESUMS toward near real-time quantitative precipitation forecast (QPF), several features were added in 2003: (1) Radar Echo Statistics for Data Quality Control, for the removal of quasi-stationary non-meteorological target (noise) (Fig. 4); (2) Doppler Velocity Dealiasing Algorithm Development (Fig. 5) Showing before and after dealiasing, For the diagnoses of internal structure of storms); (3) GIS/Surface Observation Overlay (Fig. 6); (4) Severe storm ID and typhoon track overlay (Fig. 7). The products from QPESUMS are presented in web page format.

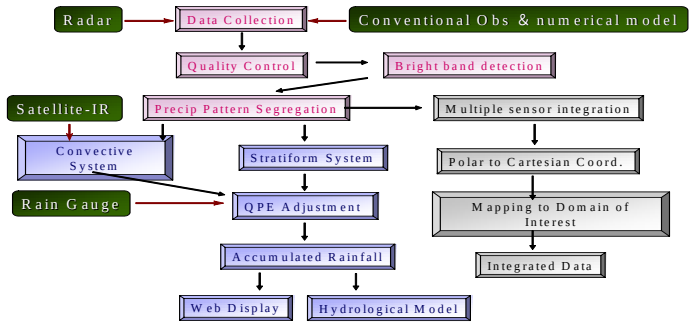
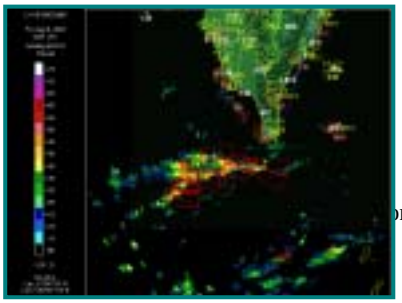
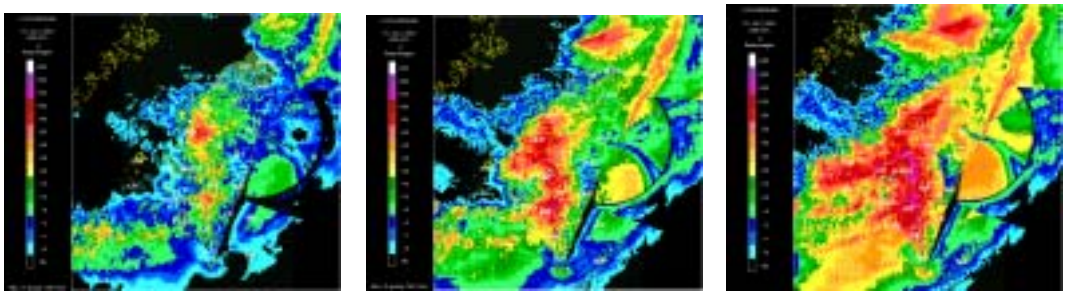


Fig. 1 Data sources and the products for QPESUMS



on QPESUMS.



(a) 1 hr accumulated QPE (b) 3 hr accumulated QPE (c) 6hr accumulated QPE

Fig. 3 The QPE, with 10-minute update cycle, made by the QPESUMS for typhoon Mindulle (2004).

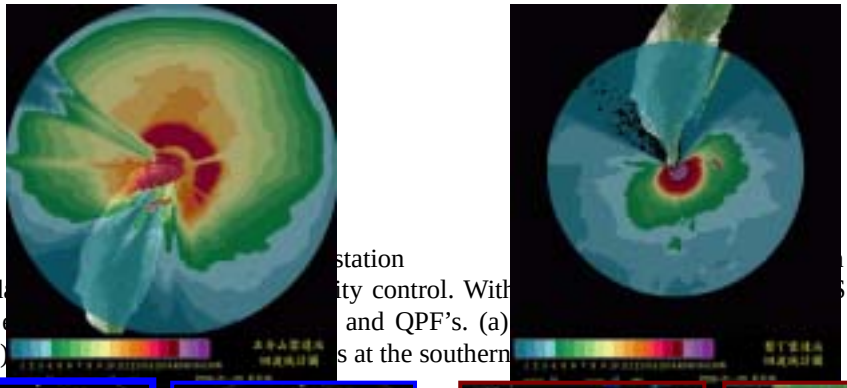
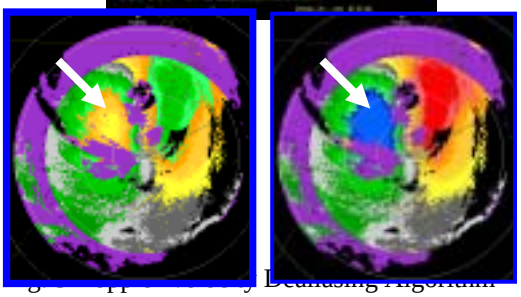


Fig. 4 Rad station
ity control. With system is able to remove the stationary and QPF's. (a) locates at the northern tip of Taiwan, (b) s at the southern



Development. With the dealiasing function, the QPESUMS system is able to more reasonably show the internal velocity structure of storm system.

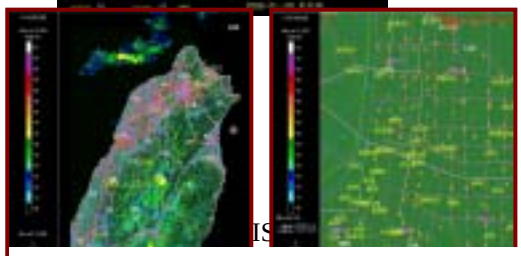
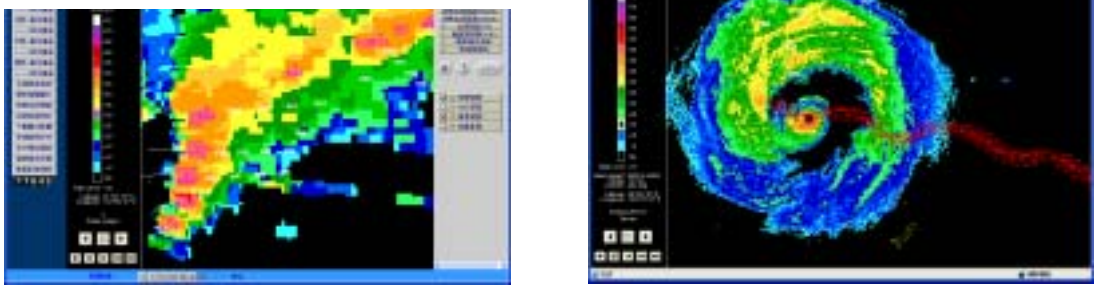


Fig. 6 GIS/Surface Observation Overlay on the products of QPESUMS. With this function, the user of QPESUMS can precisely locate the area with heavy precipitation potential.

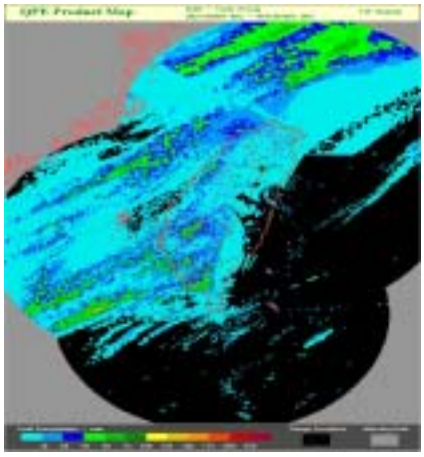


(a) Storm ID and tracking. (b) Dujuan (2003) typhoon center positioning.

Fig. 7 Convective storm identification (a) and typhoon center positioning (b).

Routine operation shows that the localized Z-R relationship, retrieved by using locally observed rainfall rates and the hybrid reflectivity of the Doppler radar in 2003 resulted in a great uncertainty of the subsequent QPE due to distinct hydrometer size distributions in different seasonal regimes. Consequently, a general Z-R relation suitable for the QPE on entire Taiwan is seemly non-existent (Chiou et al., 2004). For illustrational purpose, a case of Mei-Yu frontal system in 2003 and a wintertime cold front system in 2004 were selected to evaluate the variability of the empirical Z-R relationships used to make QPE by the QPESUMS. The hybrid reflectivity Z and the corresponding raingauge data R (directly covered by the radar pixels) are used to derive the A and b for $Z=A \cdot R^b$ via curve fitting. A Mei-Yu front covered southern Taiwan from 22UTC June 12 to 09UTC June 13, 2003 generated a mean hourly rainfall rate of 36mm (Fig. 8a). It turned out that for Z less than 30 dBZ, $Z=0.0005 \cdot R^{8.13}$ and for Z greater than 30dBZ, $Z=17.72 \cdot R^{3.0}$ will

generate most appropriate QPE's (Fig. 8b). In contrast, a wintertime cold frontal system passing northern Taiwan on February 8, 2004 with a mean hourly rainfall rate of 10mm (Fig. 9a), the associated Z-R relationship turned out to be $Z=18.65 \bullet R^{3.67}$ for Z greater than 30dBZ (Fig. 9b). With mean rainfall rates greater than 10mm/hr, the correlation coefficient between the estimated rainfall rate (thru $Z=18.65 \bullet R^{3.67}$) and the observed rainfall rate is as high as 0.89 (Fig. 9c). A long-term statistical derivation of variable A's and b's for Z-R relation based on different weather systems (such as Mei-Yu fronts, afternoon thunderstorms, typhoons, wintertime fronts, etc.) will be performed to lower the uncertainty of QPE's by the QPESUMS. The goal set for the QPESUMS is to be able to make reasonable 0-1hr QPF on the severe weather systems by the end of 2005.



(a) QPE by QPESUMS

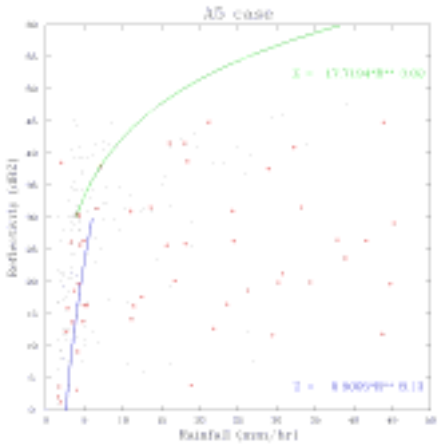
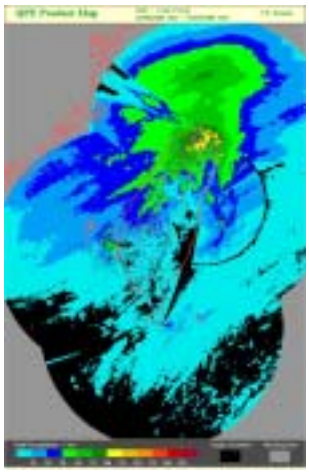
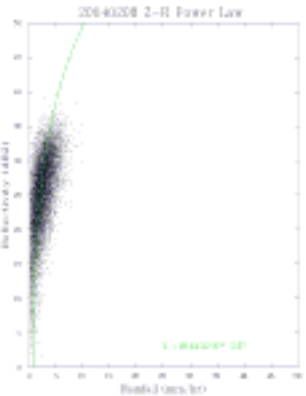


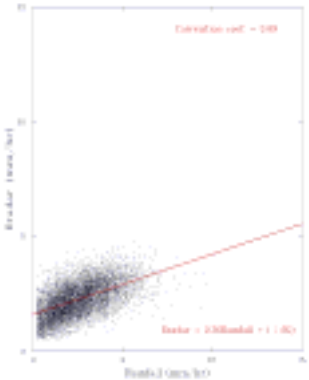
Fig. 8 (a) Accumulated QPE by QPESUMS for a Mei-Yu front case, from 00UTC 06/13 to 00UTC 06/14/2003. (b) Curve fitting of the Z-R relationship for a Mei-Yu front in Taiwan. Data of Z (ordinate) and R (abscissa) are from 22UTC June 12 to 09UTC June 13, 2003. Blue line is for Z less than 30 dBZ, and $Z=0.0005 \bullet R^{8.13}$; Red curve for Z greater than 30dBZ and $Z=17.72 \bullet R^{3.0}$.



(a) QPE by QPESUMS



(b) $Z=18.65 \bullet R^{3.67}$.



(c) QPE vs. observation

Fig. 9 Accumulated QPE by QPESUMS, for a wintertime front case, from 00UTC 02/08 to 00UTC 02/09/2004 (a). (b) Curve fitting of the Z-R relationship for a wintertime front in Taiwan for Z greater than 30dBZ and $Z=18.65 \bullet R^{3.67}$. Data of Z (ordinate) and R (abscissa) are from 00UTC February 08 to 00UTC February 09, 2004. (c) The radar estimated rainfall rate thru $Z=18.65 \bullet R^{3.67}$ (ordinate) versus the observed rainfall rate (abscissa) for a wintertime cold frontal system passing northern Taiwan on February 8, 2004 with a mean hourly rainfall rate of 10mm. The correlation coefficient is 0.89.

3. LAPS- MM5 SYSTEM

The short of hydrometers and the accompanied supporting vertical motion fields (leading to the lack of condensation and latent heat release) in the initial stage of model integration limits the short-range (0-12hr) forecasting accuracy of

precipitation by mesoscale models. To address the spin-up problem in limited-area models, data assimilation that includes the diabatic heating effect is commonly used (e.g., Molinari 1982; Davidson and Puri 1992; Chang and Holt 1994). A more advanced and systematic approach is the LAPS (Local Analysis and Prediction System; McGinley et al. 1991; Albers et al. 1996). The FSL has developed data assimilation system that ingests radar, satellite, profiler, aircraft reports, and conventional data (Fig. 10). A unique aspect of LAPS is production of a three dimensional cloud field including vapor, water, ice, mixing ratios and vertical motion estimates (Albers et al. 1996). The resulting fields are used to initialize a range of mesoscale models (e.g., MM5 (Shaw et al. 2001), RAMS (Snook et al. 1996), Weather and Research Forecasting system) with all microphysical species, which are in mass and momentum balance in model initial conditions (Schultz and Albers 2001; McGinley and Smart 2001). Using LAPS, the FSL began initializing real-time forecast system by MM5 since the fall of 2000. Based on experimental runs for the Colorado forecasting domain, the preliminary quantitative evaluation of prediction showed improved skill in forecasting clouds and precipitation in the early part (0-6 h) of the forecasts (Shaw et al. 2001). Due to its unique diabatic initialization technique, it has been dubbed the “hot start” MM5 forecast.

The uniqueness of hot-start MM5 lies in the (1) cloud analysis, which is designed to provide the user with a complete description of the hydrometers in the atmosphere, (2) moisture analysis (Birkenheuer, 2001), which can generate the three-dimensional moisture field consistent with these moisture integrations sensors, (3) wind field analysis (Albers, 1995), which is to include the Doppler radial winds via multiple-pass Barnes (1964) scheme, (4) surface analysis (McGinley et al., 1991), which is to include hourly surface observations in Taiwan area and to make the wind fields be constrained to satisfy the momentum constrain, and (5) dynamic balance scheme (McGinley and Smart, 2001), which is to ensure that the momentum and mass fields are consistent with the empirically assigned vertical motion fields based on the cloud analysis scheme. Through these data processing procedures, the 3-D structures of mesoscale systems (cloud cover, rainy area and the associated vertical motion fields, etc.) over Taiwan area can be better described in hot-start MM5 computational domain (Fig. 11).

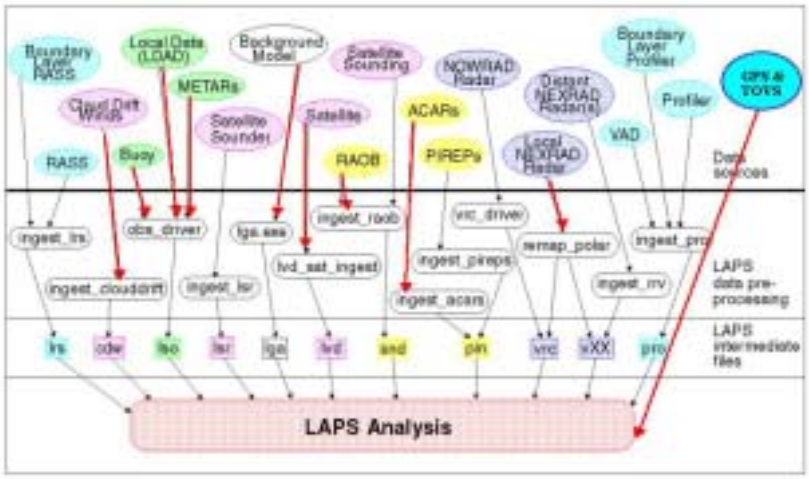


Fig. 10 Data sources for diabatic LAPS.

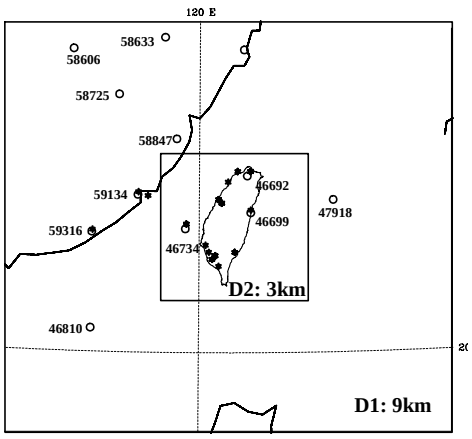


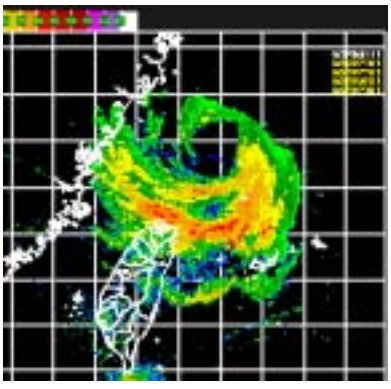
Fig. 11 Domain configuration for MM5 simulation. A stationary 3-km domain (D2) is nested within a 9-km domain (D1)

using two-way nesting interfaces. The stars and circles signs indicate the meteorological aviation routine weather report (METAR) and the sounding stations, respectively.

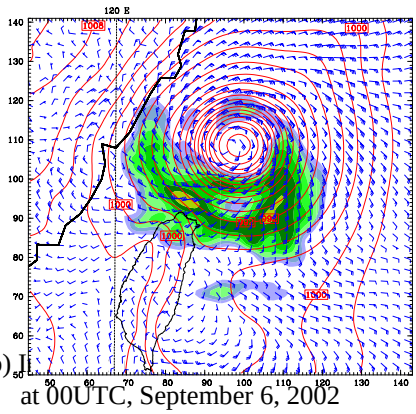
The hot-start MM5 (version 3.5) initiated by the LAPS analysis is configured in nonhydrostatic mode for the purpose of making 0-12hr short-range forecast on the severe weather systems. The computational domain, shown in Fig. 11, is a stationary 3-km domain of 151 by 151 grid points nested within a 9-km domain using two-way interfaces. The horizontal size and geographic location of the outer domain are the same as the LAPS analysis domain. Both MM5 domains extend in the vertical to 100 hPa and are resolved by 30 unevenly spaced sigma levels, with the finest resolution near the boundary layer. Two-minute-averaged terrain data are analyzed to model grids using a Cressman analysis scheme and filtered by a two-pass smoother/desmoother. For initializing the various surface categories and coastline, a two-minute-averaged vegetation/land-use and land-water mask dataset from U.S. Geological Survey are used. Initial atmospheric conditions are provided by LAPS, sea surface temperature from the National Centers for Environmental Prediction (NCEP), and lateral boundary conditions of outer domain from the CWB limited-area model. For the nested domain, the initial conditions are generated from its parent mesh. For the physics options, the explicit moisture scheme of Schultz is used, which includes prognostic equations for cloud ice and water, snow, rain, and graupel. The surface and PBL are parameterized using the five-layer soil model and medium-range forecasting (MRF) PBL scheme. The Rapid Radiative Transfer Model (RRTM) is applied and no cumulus parameterization is used. In addition, upper radiative boundary condition is applied to allow wave energy to pass through the model top.

The initial LAPS-MM5 system for Taiwan area was operational in late 2002 and the QPF products have been under evaluation for further system improvement. For the typhoon Sinlaku case analysis, Jian et al. (2003) pointed out that the assimilation of the Wu-Fen-Shan Doppler radar data could enhance the forecast definition of typhoon rainband and the subsequent short-range QPF simulations due to a better description of the typhoon's initial hydrometeorological features specified by the LAPS analysis (Fig. 12). In other words, the presence of initial hydrometeor species in LAPS had a beneficial impact on reduced precipitation spin-up time in the ensuing MM5 integration. When using the 25-mm precipitation as the verification threshold for 0-6hr QPF, the equitable threat score (ETS) was about 0.24 for LAPS-MM5 system but only about 0.01 for non-LAPS regular (cold-start) MM5 (Fig. 13). However, these radar data only play a minor role on the typhoon track simulation and the evolution of minimum sea-level pressure in this case study.

The original LAPS analysis tends to have discontinued vertical motion profile for the radar-observed cumunimbus (Cb) clouds owing to the LAPS algorithm used to discern the cloud types. A Cb cloud tends to be identified as two or three independent shallow convective clouds with different vertical motion profiles being specified. This would make the mesocale convective systems (MCS's) observed by radars be improperly represented as unorganized systems in the LAPS analysis. The evolution of existing MCS's, thus, will not be adequately simulated in the ensuing MM5 integration. To resolve this defect, Teng and Chen (2004) assign a continuous vertical motion profile through the entire Cb cloud (Fig. 14) and make the intensity and movement of an interested MCS, which generated a daily precipitation of more than 80mm, be more properly simulated during the first six-hour model integration period (Fig. 15).

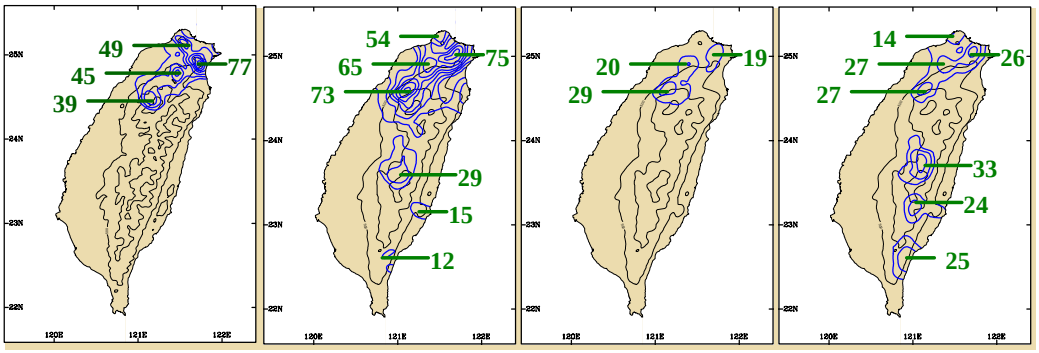


(a) Radar reflectivity of Sinlaku at 00UTC, September 6, 2002



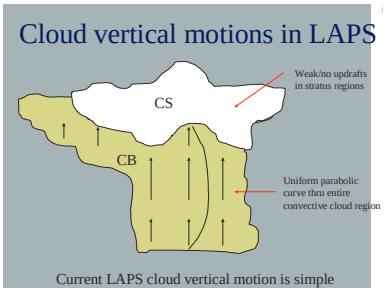
(b) I at 00UTC, September 6, 2002

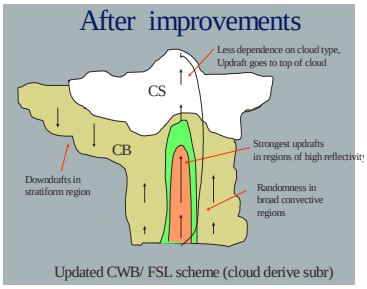
Fig. 12 The radar reflectivity of typhoon Sinlaku (a) and the corresponding initial condition of MM5 generated by LAPS at 00UTC, September 6, 2002 (Jian et al, 2003).



(a) Raingauge observation (b) Hot-start MM5 (c) Cold-start MM5 (d) Hot-start MM5 without radar data

Fig. 13 Six hourly rainfall amount from (a) raingauge observation, (b) hot-start MM5, (c) cold-start MM5, (d) hot-start without radar data, from 00 to 06 UTC, September 6, 2002 (Jian et al, 2003).

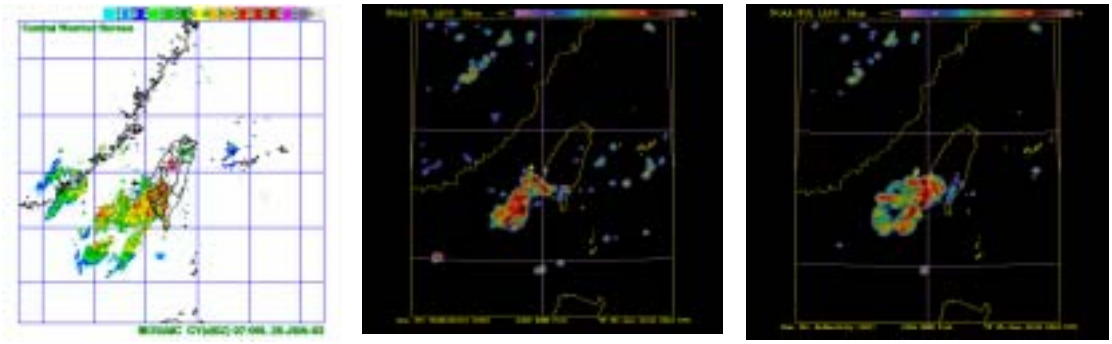




(a) Discontinued vertical motion profile in a Cb specified in the original LAPS.

(b) Adjusted and continuous vertical motion profile in a Cb.

Fig. 14 (a) The vertical motion fields in a Cb cloud assigned in the original LAPS and (b) The adjusted (continuous) vertical motion fields in a Cb.



(a) Radar reflectivity of a MCS

(b) Hot-start MM5 3 hr simulation using discontinued vertical motion profile in the original LAPS.

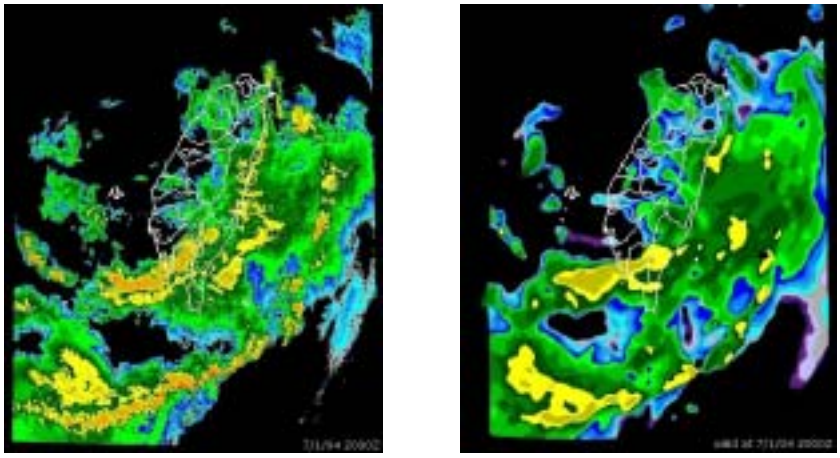
(c) Hot-start MM5 3 hr simulation using adjusted (continuous) vertical motion profile Specification

Fig. 15 (a) The observed radar reflectivity valid at 23UTC, June 25, 2003; (b) Simulated radar reflectivity by hot-start MM5 3 hr forecast valid at the same time as (a) using the original vertical motion assignment in LAPS; (c) Simulated radar reflectivity by MM5 3 hr forecast valid at the same time as (a) but using continuous vertical motion fields in a Cb.

Routine operation shows that the LAPS hot-start MM5 has higher capability than the cold-start (traditional) MM5 to predict the strength and location of heavy precipitation systems (more than 35mm/hr) during the first 12-hour time integration, yet prone to over-predict the rainfall rate when precipitating system was weaker.

4. SUMMARY AND DISCUSSION

As stated above, the VSRFS is under intensive development in order to satisfy the increasing need for short-term and severe weather forecasts. The QPESUMS has been installed in four government agencies in charge of hazard mitigation in 2003 and three others in 2004. The responses from the QPESUMS users are the bases for future system improvement. Future tasks for QPESUMS are: (1) the long-term statistical derivation of variable A's and b's for Z-R relation based on different weather systems, (2) 0-1hr QPF technique development (Fig. 16), (3) cross sectional display of storm systems for diagnostic purpose (Fig. 17), (4) inclusion of lightning data for further segregation of convective and stratiform precipitation and for better estimations of convective precipitation (Fig. 18), (5) inclusion of dual-polarization techniques for a more precise segregation of convective and stratiform precipitation and etc. The long-term goal set for the QPESUMS is to be able to make reasonable 0-2hr QPF on the severe weather systems.

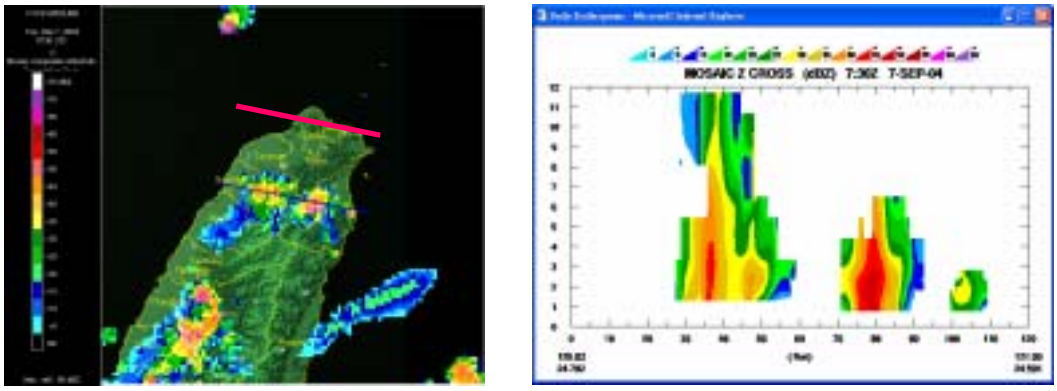


(a) Observed radar reflectivity at 20UTC, July 1, 2004

(b) 1hr radar reflectivity forecast valid at 20UTC, July 1, 2004

Fig. 16 Illustration of 1hr radar reflectivity forecast for the MCS's associated with typhoon Mindulle valid at 20UTC, July 1, 2004. (a) Observed radar reflectivity, (b) 1hr radar reflectivity forecast.

For the LAPS MM5 system, many challenging tasks related to the cloud analysis, dynamic and thermodynamic balance schemes are to be overtaken in the forthcoming years. Other future tasks for LAPS MM5 system are: (1) the design of a real-time verification system for precipitation, wind, temperature, etc., for user's reference and system improvement, (2) inclusion of more non-conventional data sources, such as satellite winds (Fig. 19), for a better description of the atmospheric states, (3) the use of Weather Research and Forecasting (WRF, Thompson et al., 2004) model in connection with the LAPS, for adding another short-term forecast reference (Fig. 20).



(a) Reflectivity of a storm in northern

(b) Vertical reflectivity profile along the line in

Taiwan in (a)

Fig. 17 Illustration of radar reflectivity cross section of a convective system in northern Taiwan. (a) Reflectivity of a storm system, (b) The vertical reflectivity profile along the line in (a).

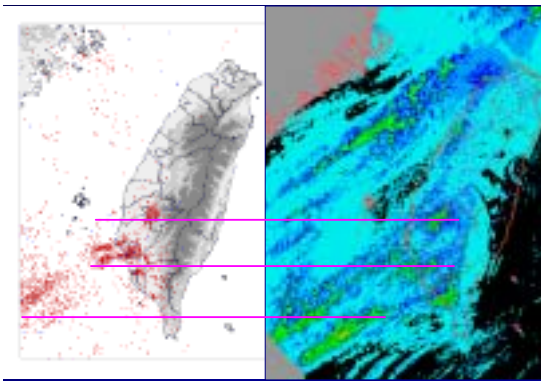


Fig. 18 The inclusion of lightning data in the QPESUMS for a further segregation of convective and stratiform precipitation and for a better estimate of QPE/QPF.

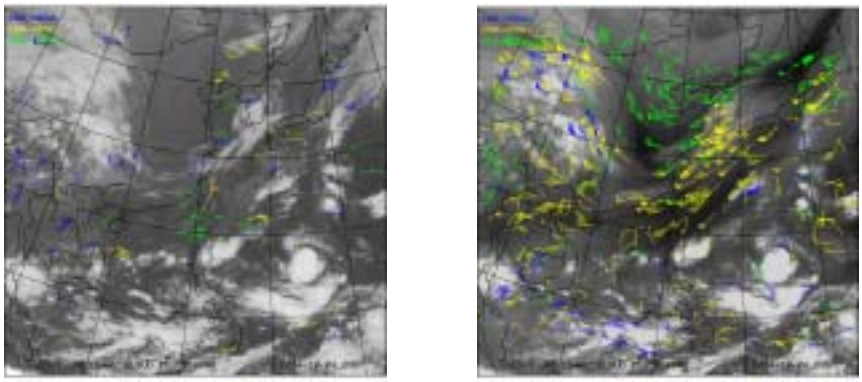
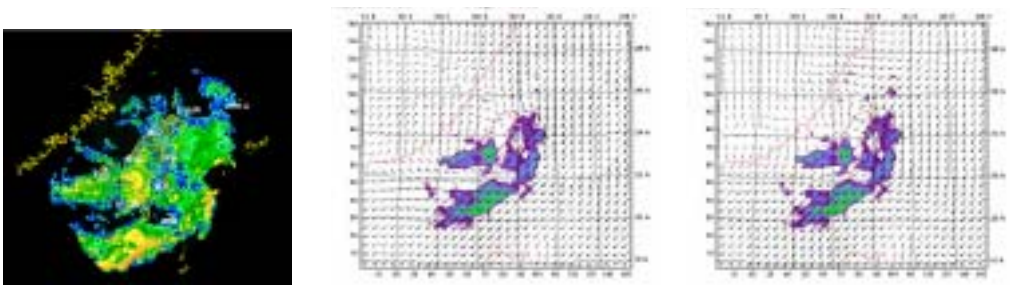
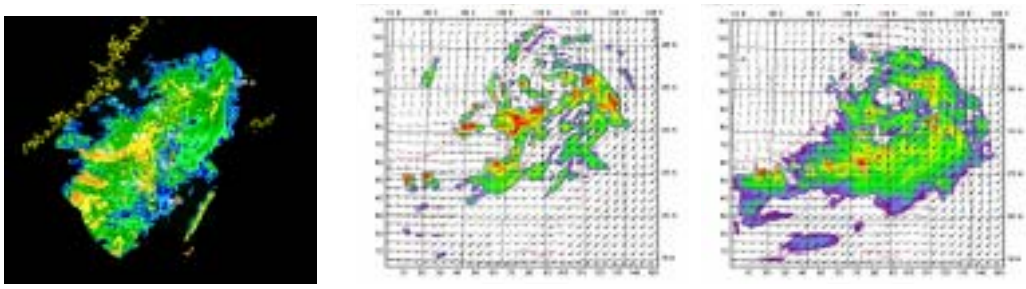


Fig. 19 Cloud motion (satellite) winds of eastern Asia derived from GOES-9 valid at 00UTC, October 4, 2004. (a) lower-level satellite winds, (b) upper-level satellite winds. The satellite wind products are operational in August 2004 and automatically generated half hourly in MSC/CWB. Special thanks go to Dr. Chris Velden of CIMSS, University of Wisconsin.



(a) Radar reflectivity of Mindulle at 00UTC, July 2, 2004 (b) Initial reflectivity for hot-start MM5 (c) Initial reflectivity for hot-start WRF



(d) Radar reflectivity of Mindulle at 06UTC, July 2, 2004 (e) 6hr reflectivity prediction by hot-start MM5 (f) 6hr reflectivity prediction by hot-start WRF

Fig. 20 Numerical simulations of typhoon Mindulle (2004) by hot-start MM5 and hot-start WRF. (a) Radar reflectivity of Mindulle valid at 00UTC, July 2, 2004, (b) Initial reflectivity field and wind field at 3km and 1 km height, respectively, for hot-start MM5 at 00UTC, July 2, 2004, (c) same as (b), but for hot-start WRF, (d) same as (a), but valid at 06UTC, July 2, 2004, (e) 6 hr prediction of reflectivity field and wind field at 3km and 1 km, respectively, for hot-start MM5 at 06UTC, July 2, 2004, (f) same as (e), but for hot-start WRF.

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