出國報告(出國類別：其 他)

出席「航空氣象現代化作業系統強化及支援計畫」協調會議報告書

服務機關：交通部民用航空局飛航服務總臺

姓名職稱：張友忠 主任氣象員

派赴國家：美國

出國期間：97 年 10 月 13 日至 97 年 10 月 19 日

報告日期：98 年 1 月 6 日

參加「航空氣象現代化作業系統強化及支援計畫」協調會議報告書

摘　要

交通部民用航空局(簡稱民航局)為提升臺北飛航情報區之航空氣象服務品質，提供符合國際規定及符合民航業界需求之航空氣象產品，於民國 86 年 7 月起推動航空氣象現代化計畫，由美國國家大氣研究大學聯盟所屬之美國國家大氣科學研究中心協助，於民國 91 年 7 月建置完成航空氣象現代化作業系統(The Advanced Operational Aviation Weather System，AOAWS)。

由於當時受到預算經費限制，部份功能尚未完全涵蓋於 AOAWS 系統中，且科技發展迅速，為持續引進新的航空氣象預報及資料整合技術，經奉行政院核定，於民國 95 年起至 99 年進行為期五年的「航空氣象現代化作業系統強化及支援計畫（Advanced Operational Aviation Weather System Enhancement and Support，AOAWS-ES）」，以持續提升民航局航空氣象作業水準。

今（97）年為 AOAWS-ES 計畫之第三年，本年度 AOAWS-ES 計畫中執行項目包含亂流與積冰效能校驗與新的演算法評估的工作，另外，中尺度氣象模式的強化工作亦是本年度的工作重點項目，皆為此次協調會議的主要議題。另參訪美國國家海洋暨大氣總署(National Oceanic and Atmospheric Administration，NOAA)博德市的地球系統研究室(Earth System Research Laboratory，ESRL)，瞭解目前最新氣象預報作業及發展概況，希能提供國內航空氣象業務發展參考。

參加「航空氣象現代化作業系統強化及支援計畫」協調會議及「航空氣象業務協調聯繫　」報告書

目　次

壹、目的

交通部民用航空局(簡稱民航局)為提升臺北飛航情報區之航空氣象服務品質，提供符合國際規定及符合民航業界需求之航空氣象產品，於民國 86 年 7 月起推動航空氣象現代化計畫，由美國國家大氣研究大學聯盟（the University Corporation for Atmospheric Research，UCAR）所屬之美國國家大氣科學研究中心（the National Center for Atmospheric Research，NCAR）協助，於民國 91 年 7 月建置完成航空氣象現代化作業系統（Advanced Operational Aviation Weather System，AOAWS）。

由於當時受到預算經費限制，部份功能尚未完全涵蓋於AOAWS系統中，且科技發展迅速，為持續引進新的航空氣象預報及資料整合技術，經奉行政院核定，於民國 95 年起至 99 年進行為期五年的「航空氣象現代化作業系統強化及支援計畫」（the Advanced Operational Aviation Weather System Enhancement and Support，AOAWS-ES），以持續提升民航局航空氣象作業水準。

為了解 AOAWS-ES 計畫本年(97)度第 11 號執行辦法（Implementation Agreement No.11，IA＃11）實際執行進度，職等至科羅拉多州博德市與 NCAR 協商 AOAWS-ES 計畫中有關作業需求與各功能建置的問題。本年度 AOAWS-ES 計畫中執行項目包含亂流與積冰效能校驗與新的演算法評估的工作，另外，中尺度氣象模式的強化工作亦是本年度的工作重點項目，皆為此次協調會議的主要議題。

此行另參訪美國國家海洋暨大氣總署(National Oceanic and

Atmospheric Administration，NOAA)博德市的地球系統研究室(Earth System Research Laboratory，ESRL)，瞭解目前最新氣象預報作業及發展概況，希能提供國內航空氣象業務發展參考。

貳、過程

職等於民國 97 年 10 月 13 日（星期一）搭乘桃園機場下午 6 時 40 分長榮航空 BR12 班機前往美國，於 10 月 13 日下午抵達洛杉磯機場，20 時 04 分轉搭美國國內線邊境航空 FR407 班機前往科羅拉多州丹佛市，抵達丹佛已是晚上 23 時 16 分，搭乘計程車至博德市的旅館已是午夜 1 點左右。

10 月 14 日（星期二）上午至NCAR Foothills Lab展開協調會議，議程如附件一。首先由Bill Mahoney簡介今年的各項工作內容，並介紹相關工作的研發團隊人員給我們認識。接著由Bruce Carmichael簡報FAA新一代航空氣象服務計畫(如附件二)，然後Frank McDonough簡報FAA最新積冰計畫(如附件三)，Jordan Powers簡報模式工作項目(如附件四)，Bob Sharman簡報FAA 最新亂流計畫(如附件五)，將FAA目前航空氣象相關研究計畫的最新進展及與航空氣象現代化產品之差異做詳細的比較。

10 月 15 日（星期三）前往Foothills Lab展開相關的會議，首先由JMDS程式研發者Aaron爲大家展示最新的功能，並討論未來可能的計畫。在簡短茶點時間結束後，由COMET計畫的Warren Fodie、Timothy Spangler爲大家介紹「針對風和低空風切撰寫機場天氣預報」的課程，這是免費的線上課程，詳細的課程內容可在COMET的遠距航空教學網頁上找到http://www.meted.ucar.edu/dlac/website/index.htm。最後，由Gary Cunning主持今年度工作內容及明年度工作內容的解說和討論(如附件六)。

10 月 16 日（星期四）由 Celia Chen安排參觀美國國家海洋暨大氣總署（NOAA），由NOAA地球系統研究實驗室(ESRL)的全球系統部門的孟繁春博士爲大家解說該實驗室的各項工作(如附件七)，下午五時至丹佛機場搭乘

晚上 21 時邊境航空F9667 班機，於晚上 23 時抵達舊金山國際機場。10 月 17 日（星期五）與長榮派駐舊金山代表會晤並交換對於航空氣象服務現況之意見，下午稍事休息後，搭乘 10 月 18 日（星期六）凌晨 1 時 30 分長榮航空BR17 班機，於臺北時間 10 月 19 日（星期日）清晨 6 時抵達臺灣桃園國際機場。

參、心得

一、AOAWS-ES 計畫協調會議

本次協調會議仍由 Celia 女士協助辦理各項參訪及會議行程，雖然她已經不是 NCAR 的全職工作人員，但是經由她的協助，整個行程圓滿完成。另外，本年度負責計畫的主要工程師由 Gary Cunny 擔任，在這近一年的溝通和信件往來，Gary 認真負責的態度令人感佩，藉由協調會議的進行，雙方面對面針對今年業務的推動和明年業務的工作項目進行溝通和說明，彌補了語言造成的誤解。AOAWS-ES 的系統架構是由許多高度模組化的系統程式所構成，人員的異動不致造成系統的無法運作，但是這個系統仍在持續地發展，隨著資料量和資料種類的增加，以往未曾發生的資料碰撞或是網路問題都陸續地發生，此次會議內容提及新增一套 FTP 伺服器，做為未來飛航管理系統（Air Traffic Management System，ATMS）接取氣象資料之界面，為此，職等除說明建置此伺服器的緣由及用途外，亦與 Gary 交換了建置的方式及各項界面可能需要修改的意見，未來數個月將持續連繫此項工作的進行。

二、參訪 NOAA 辦公室

美國國家海洋暨大氣總署(NOAA)在博德市的地球系統研究實驗室(Eearth System Research Laboratory，ESRL)是作業單位，也是研究單位，主要工作是提供全球的環境資訊(如火山爆發、野火燃燒區域等)及短期的天氣預報和長期氣候預報。在參訪的行程中，由孟繁春博士帶領並介紹各實驗室的工作，並且參觀了所謂的 SOS，也就是 Science On a Sphere，他特別提到臺灣的自然科學博

物館在今(97)年5月成爲全球除了美國以外的第一個建置此項系統的機構。其系統資訊主題涵括大氣、陸地、海洋、模式和模擬及附加資料，是一個展示全球各項資訊很好的平臺，跳脫了以往的二維空間的展示。另外，隨著近年電腦計算能力的大幅提升，ESRL使用全新設計的全球天氣預報模式，稱爲定容20面體模式(finite-volume icosahedral model，FIM)，用以解決模式設計的邊界問題。目前此種模式已可產製相當好的預報產品，國內中央氣象局亦有與NOAA進行相關之合作計畫，若是未來成功引進國內使用，亦可提供給我們AOAWS系統相當多的幫助。

三、參訪長榮航空舊金山辦事處

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

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

提供外，飛行員有需要時也會自行上網至美國本土及國內民航局航空氣象服務網站(http：www.aoaws.caa.tw)查看所要資料。

肆、結語與建議

一、協調會議

本（97）年度在 NCAR 舉辦的協調會議，由 NCAR 的報告中，可以明確看出第 11 號執行辦法（IA＃11）的各項工作進度皆已達完成的階段，且各項工作也都呈現令人滿意的成果，茲將成果說明如下:

(一)積冰產品及演算法評估報告，對於目前依照天氣研究及預報模式(Weather Research and Forecast，WRF)預報的積冰產品仍有積冰區域未預報到的情形，雖已比前一代使用 MM5 中尺度天氣模式產製的積冰預報產品改善許多，但是此份評估報告認爲若用更新過的演算法(Forecast Icing Product，FIP)來取代現行的演算法(Fuzzy logical algorithm)，將可避免預報誤失的情形。

(二)亂流產品及演算法評估報告，對於目前依 WRF 模式預報資料以現行亂流演算法得到的亂流預報，已比前一代以 MM5 模式預報資料爲基礎所計算的亂流產品好，減少了許多過度預報的情形。此份報告說明 NCAR 現在爲 FAA 進行新的亂流預報演算法(GTG2)，比現行的預報結果更好，可有效減少預報誤失或是過度預報的情況。

(三) 中尺度氣象預報模式的強化，本年度主要的工作是將衛星輻射資料經由資料同化的技術補強觀測資料的不足，以加強模式預報的效能。而在颱風預報方面，利用植入颱風渦旋至模式初始資料的方法，於今（97）年颱風季來臨前完成上線，並且相當程度地改善了颱風的路徑預報。目前模式已升級至 2.2 版本。

建議:

(一)積冰和亂流產品爲航空氣象服務重點之天氣預報項目，爲能有效

地產製該預報，應持續與 NCAR 合作發展此項科技應用。同時，應藉由各項航機報告來分析預報的可靠性，以持續提升此項產品的精準和有效性。

(二)航空氣象現代化系統強化及支援計畫（AOAWS-ES）自 95 年開始執行至今，已歷經三年，計畫中各項工作之雛形皆已完成，因此，雙方的計畫協調人員雖有異動，但對於整個計畫的推動仍不致於有太大的影響。惟為後續計畫之順利執行，持續安排雙方管理人員之定期互訪，實有助於各項事務之溝通。

二、NOAA 參訪

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

三、長榮航空舊金山辦事處參訪

經由長榮航空舊金山辦事處翟主任對於民航局航空氣象服務感到滿意的反應來看，準確的航空氣象預報確實對航空公司的營運產生相當大的效益，其中又以颱風風力及低能見度預報最為重要。由於今年幾個侵臺颱風，臺北航空氣象中心的機場天氣預報，皆能準確的掌握到桃園國際機場的風力變化趨勢，使長榮航空由舊金山飛桃園之國際線班機皆能做出適當的調度和安排，有效解決該辦事處運務作業之困難。為提供國籍航空公司更好

的航空氣象服務，建議臺北航空氣象中心應多鼓勵預報人員多著力於颱風風力及低能見度預報之客觀研究上，以彌補人爲主觀經驗之不足。

伍、附錄

附件一 協調會議議程

UCAR-CAA AOAWS-ES Project Fall 2008 Meeting Agenda

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

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

10/15/2008 (FL-2 Room 3099)

Time	Activity	Host/Speaker
8:30am	Pick-up from hotel	Celia Chen
9:00-11:00 am	UCAR annual meetings: Forum on Climate Change	Celia Chen
12:00PM	Lunch (FL-2 cafeteria)	
01:15pm	- Demo of the newest AOAWS display functions - AOAWS-ES project related discussions, including the following topics: - the current system, - IA#12, and - Phase-III.	Bill, Gary, Aaron, Steve, Paul, Celia, Bill Kuo, Jordan, Jim
03:00pm	Coffee/Tea break	

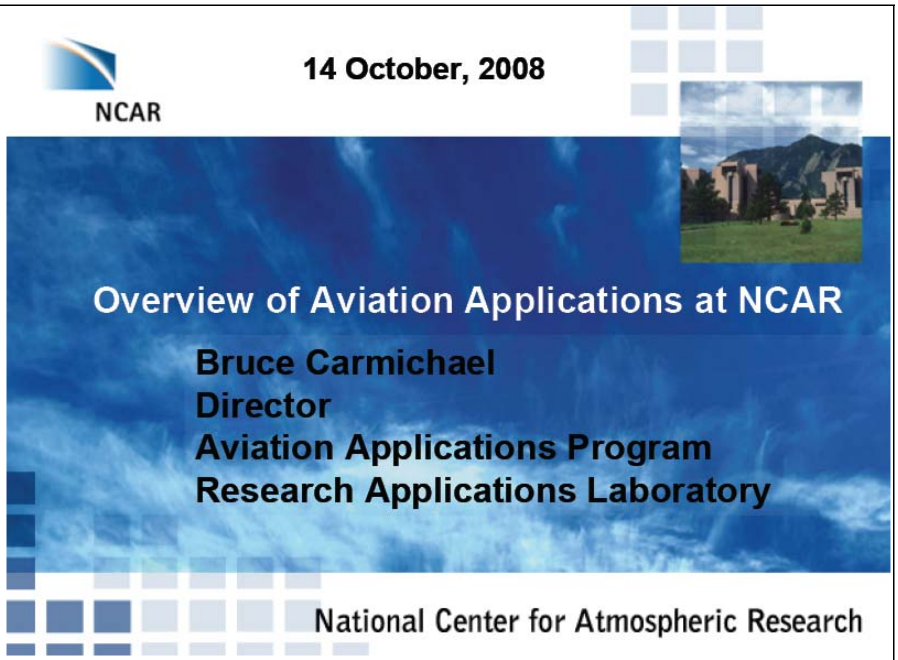
03:15pm	"Writing TAFs for Winds and Low-Level Wind Shear"	Warren Rodie, Timothy Spangler (COMET)
03:45pm	Continue with AOAWS-ES project related discussions, if needed.	Bill, Gary, Aaron, Steve, Paul, Celia
6:30pm	Dinner (Golden Lotus)	Bill Mahoney

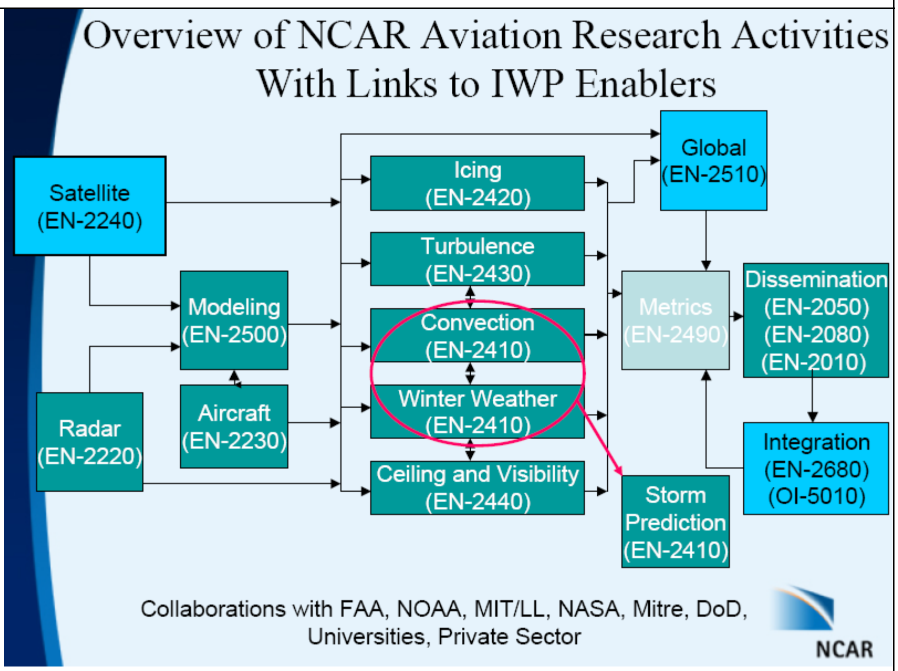
10/16/2008

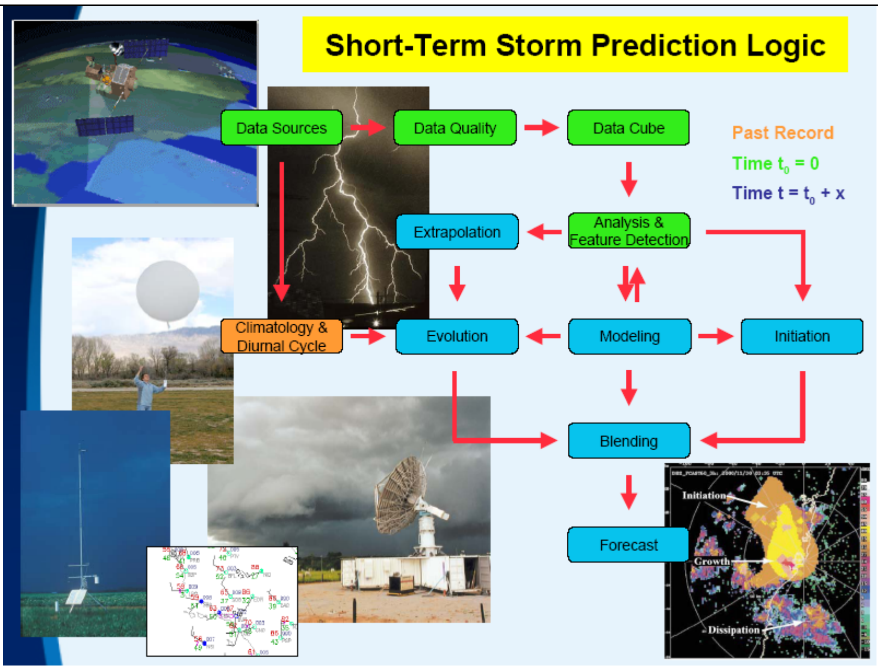
9AM: Visiting NOAA Boulder campus

PM: Leaving Boulder

附件二 航空氣象產品應用簡報

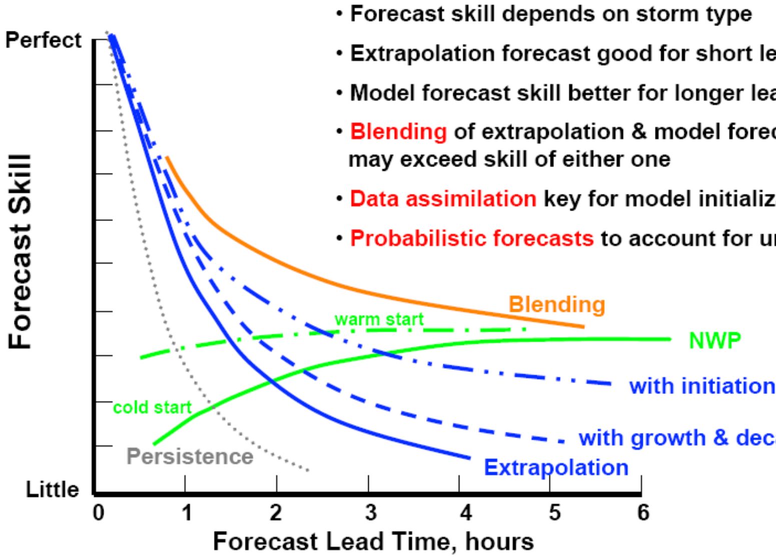






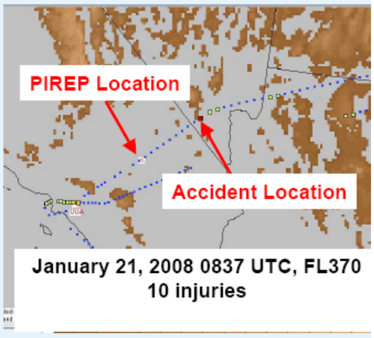
Progress Toward Improved Forecast Skill

- Forecast skill depends on storm type
- Extrapolation forecast good for short lead times
- Model forecast skill better for longer lead times
- Blending of extrapolation & model forecasts may exceed skill of either one
- Data assimilation key for model initialization
- Probabilistic forecasts to account for uncertainty



In situ measurement and reporting system

- **Motivation**
  - Augment/replace subjective PIREPs with objective state-of-the-atmosphere turbulence measurements.
- **Features:**
  - Atmospheric turbulence metric: eddy dissipation rate (EDR), actually $\varepsilon^{1/3}$ ($m^{2/3}$ / s)
  - One minute peak and mean
  - Completely automated
  - Position accuracy within 10-15 km vs average 50 km pireps.
  - Adopted as ICAO Standard
  - Can be converted to RMS-g given information about aircraft

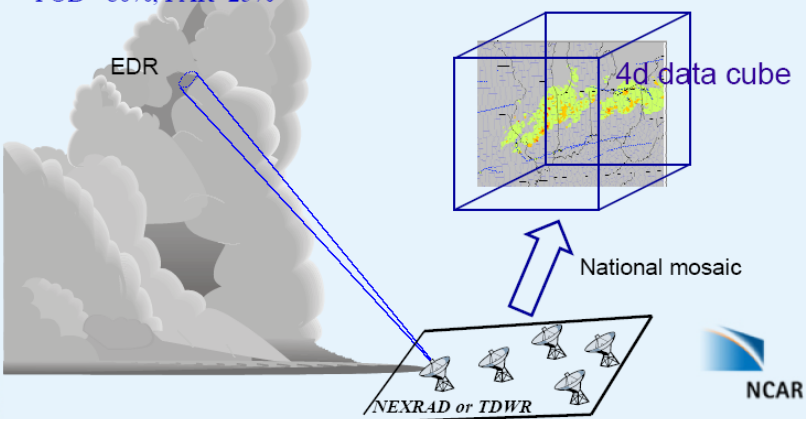


Example of PIREP location error

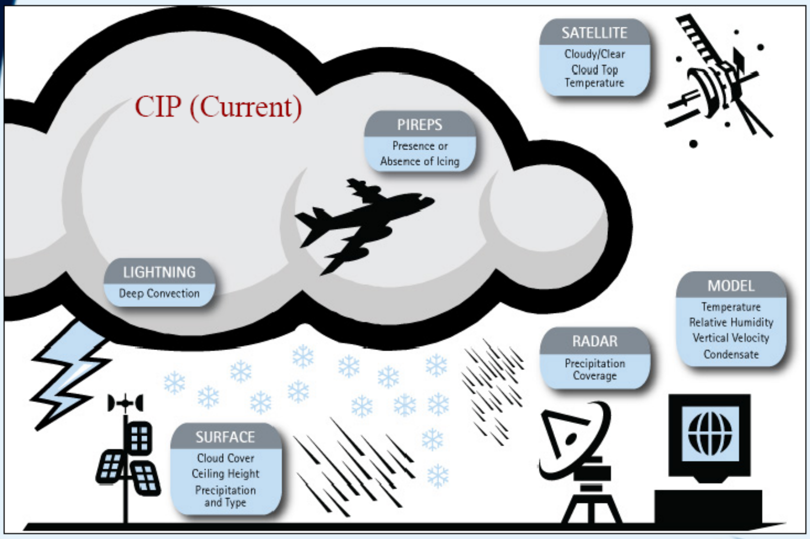
NCAR

Remote Sensing - NEXRAD in-cloud Turbulence Detection Algorithm (NTDA)

- High-resolution, rapid-update atmospheric turbulence intensity detection capability for aviation using NEXRAD radar data
- Doppler spectral width ⇒ EDR (same as *in situ* measurements!)
- POD ~80%, FAR~25%



NCAR

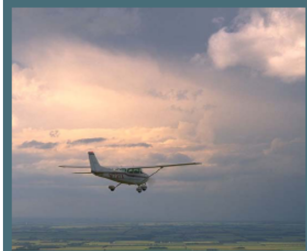


NCAR

C&V: Development Thrusts for NextGen

Airport Efficiency
- Approx 1/3 of Wx-related delays due to impacted C&V.
- Key Issue: *Landing & taxi visibility in the terminal area.*

- Initial (2013) focus on 1-2 Terminals.
- Hi-res space/time.
- Probabilistic C&V forecast info for DSS's.
- 1-12 hr to start.
- Embedded in CONUS 5 km grid.
- Future RVR forecast.



In-route Safety
- 60-65 GA deaths/year.
- GA pilot limitations:
  - Perhaps VFR only.
  - Limited experience. & equipment.
- GA pilot strategy: *Avoid or exit inadvertent IFR.*

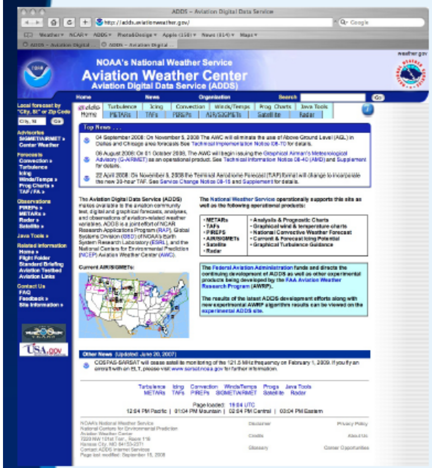
- C, V & Flt Cat.
- Real-time METAR graphics & forecast.
- Probabilistic gap-filling.
- Probabilistic 1-12h forecast.
- Emphasize glance value.

NCAR

The Systems

http://adds.aviationweather.gov

Operational ADDS



http://weather.aero

Experimental ADDS

NCAR

NextGen Network Enabled Weather (NNEW)

Virtual 4-D Weather Data Cube

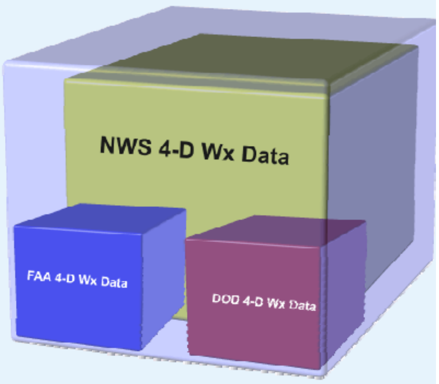
The Cube:

Products

NOAA/NWS is the primary source of weather data

Initial Operating Capability (IOC) in 2012/2013

•First cut of the 4D cube
•Nearly finalized (but not exhaustive) set of products



Virtual 4-D Weather Data Cube

26

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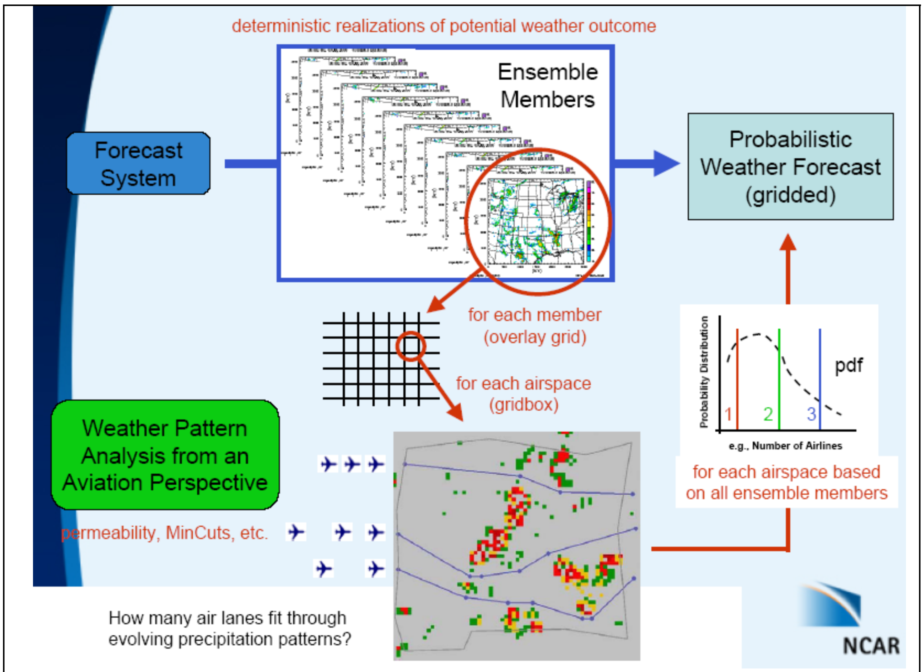
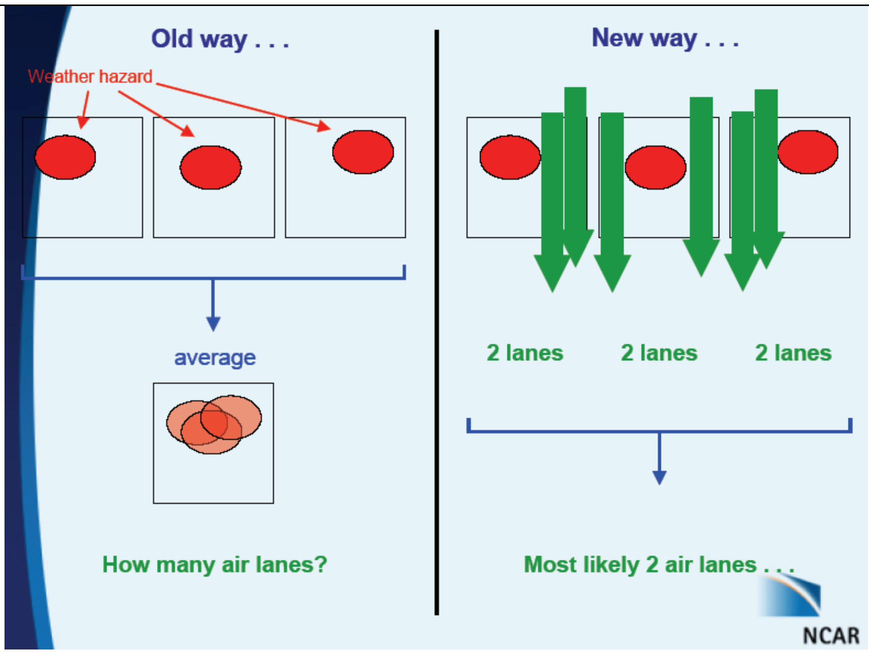
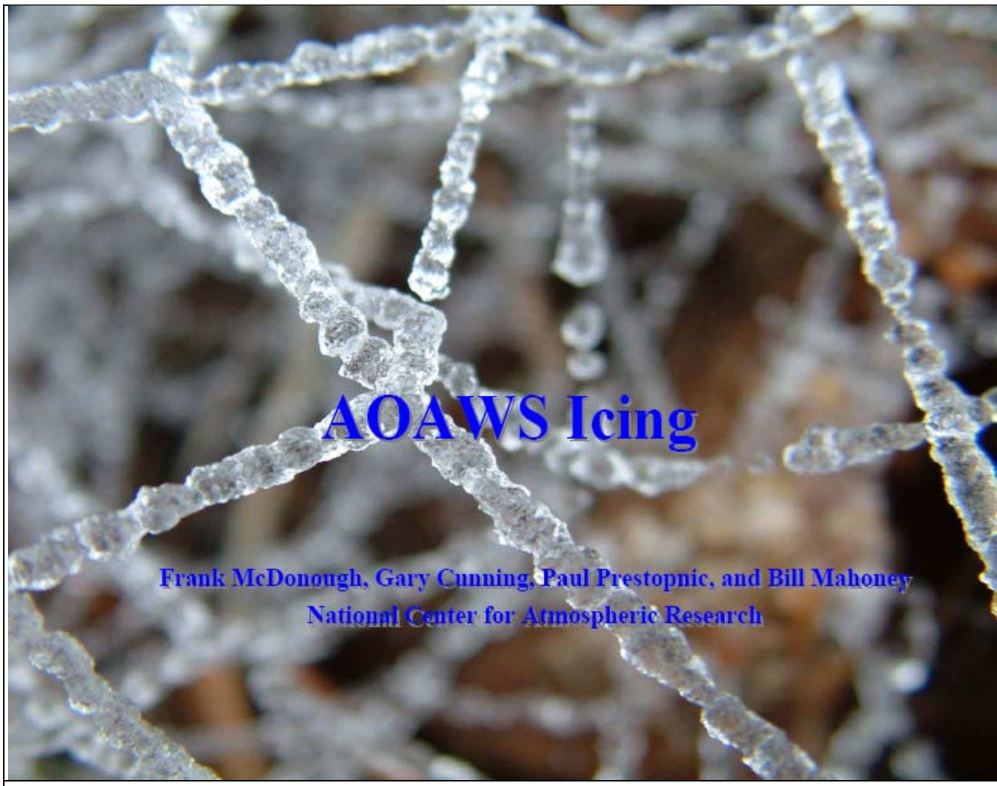


deterministic realizations of potential weather outcome
Ensemble Members
Forecast System
Probabilistic Weather Forecast (gridded)
for each member (overlay grid)
for each airspace (gridbox)
pdf
Probability Distribution
e.g., Number of Airlines
for each airspace based on all ensemble members
Weather Pattern Analysis from an Aviation Perspective
permeability, MinCuts, etc.
How many air lanes fit through evolving precipitation patterns?
NCAR



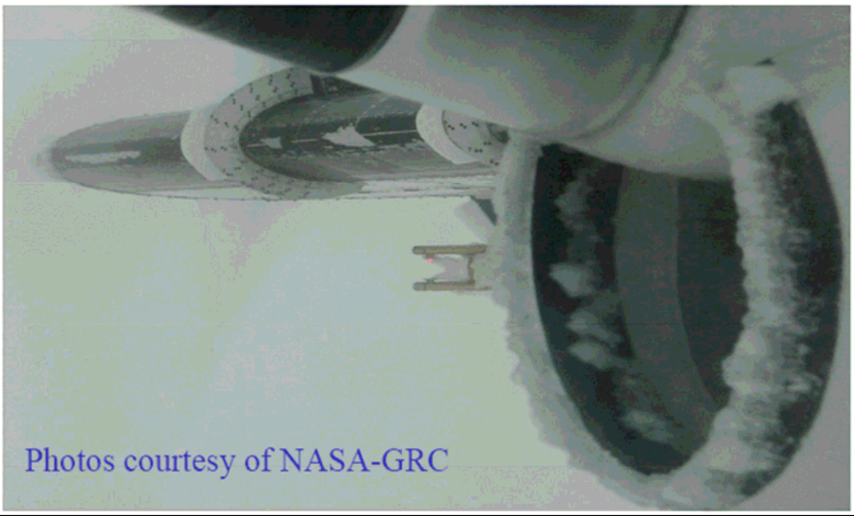
Old way . . .
Weather hazard
average
How many air lanes?
New way . . .
2 lanes
2 lanes
2 lanes
Most likely 2 air lanes . . .
NCAR

附件三 積冰校驗簡報資料

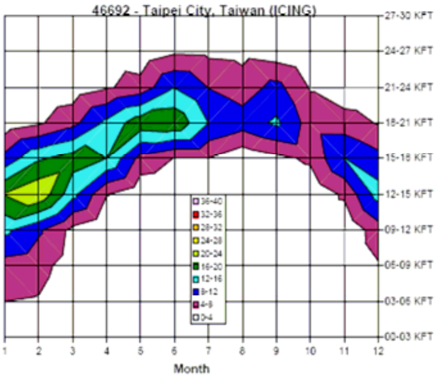


Aircraft Icing

- Supercooled (T < 0°C) liquid water cloud/precipitation droplets
- Freeze to the airframe
- Severity -- function of (Temp, LWC, Drop Size, and Aircraft type)



Icing in Taiwan



Taipei icing climatology
from soundings

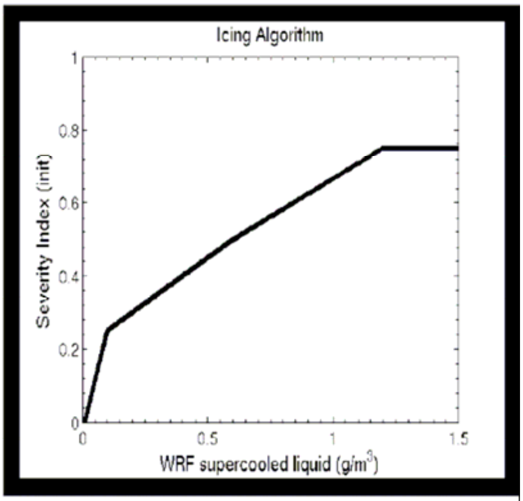
Existing AOAWS Icing Algorithm

- Requires model to forecast supercooled liquid water exceeding 0.01 g/m^3
- Initial Severity index multiplied by 1.5 if temperature (T) between

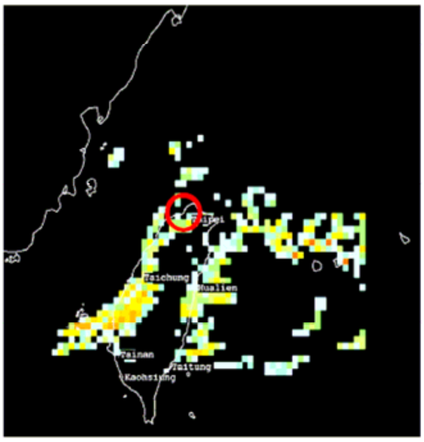
  0C < T < -10C

(assumes clear ice will form and it is more dangerous)

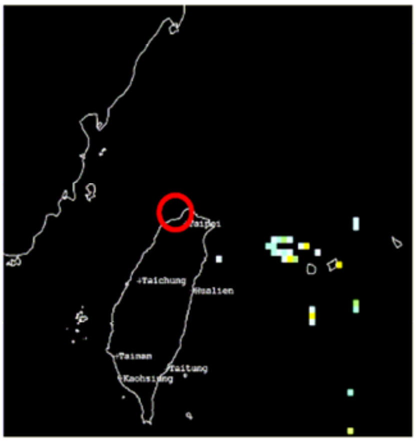
Recently proven to not necessarily be the case



Example 1 of icing algorithm



FL100 (just below PIREP)
Icing forecast due to supercooled liquid forecast



FL130 (within PIREP)
Icing not forecast due to incorrect condensate phase forecast.

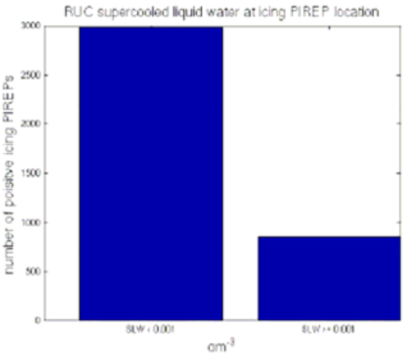
Example 1 of icing algorithm

Pilot Report (PIREP)
Serious icing reported between FL110 - FL150 east of Taipei

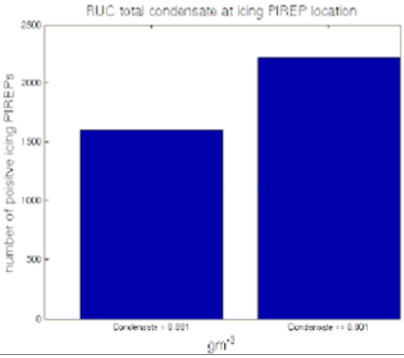
Finding - 5-km model, 6-hr fcast incorrectly predicted a glaciated cloud - no icing identified

Model microphysics?

Supercooled liquid water (SLW)
•captures ~30% of icing PIREPS
•Small volume of airspace
•Icing likely present when forecast
•Icing often present when not forecast

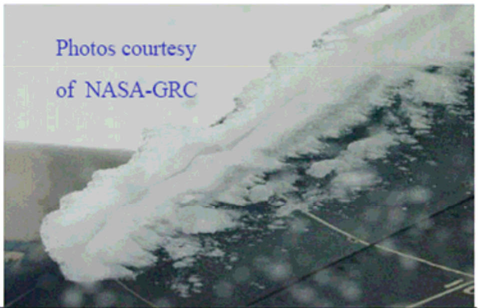


Total condensate: Ice phase + SLW
•captures ~60% of icing PIREPS
•Much larger volume of airspace covered
•SLW in real atmosphere misidentified as ice phase in model

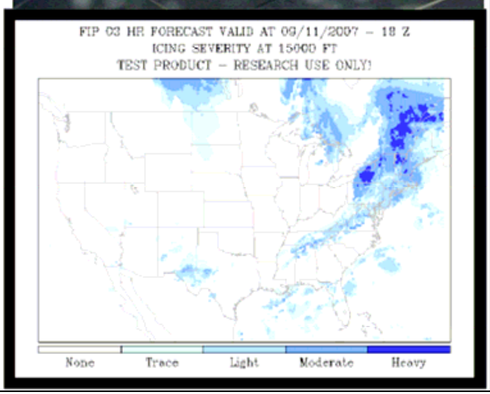


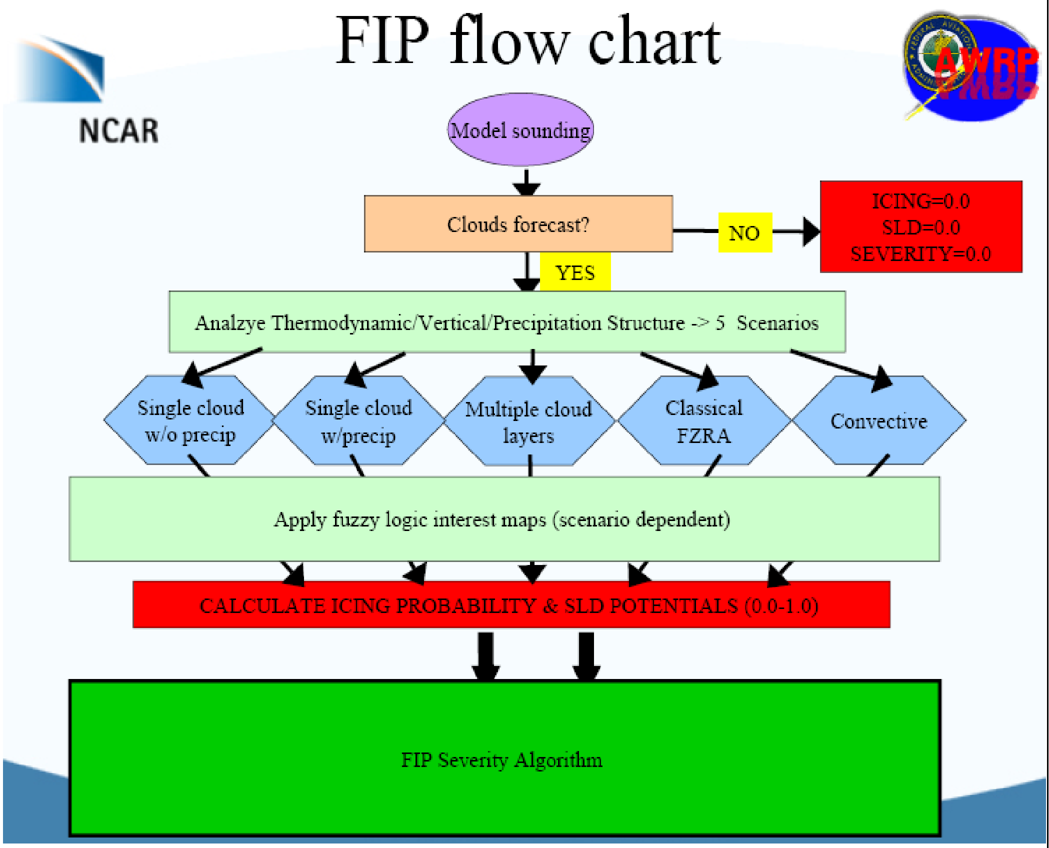
Forecast Icing Product (FIP)

- Fuzzy Logic Algorithm
  - Operational NWS guidance product
  - Provide aviation community forecasts the probable locations of clouds and precipitation likely to contain icing conditions



- 3 output fields
  - Icing Probability – predicts probability supercooled liquid water (SLW) present
  - SLD potential – predicts possible large drop icing conditions
  - Icing severity – predicts expected severity of the icing conditions





Background: Fuzzy Logic Membership Functions

- Build cloud structures from model data

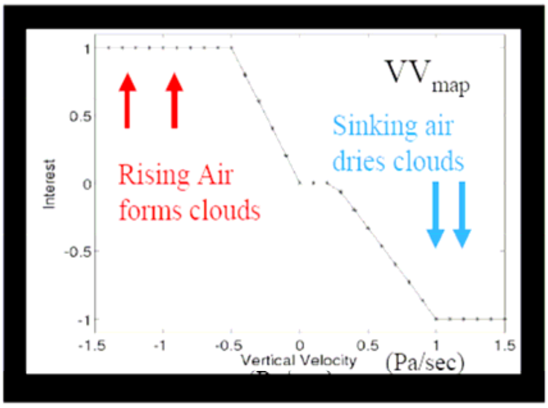
•Extract icing-relevant data from model fields within cloud structure

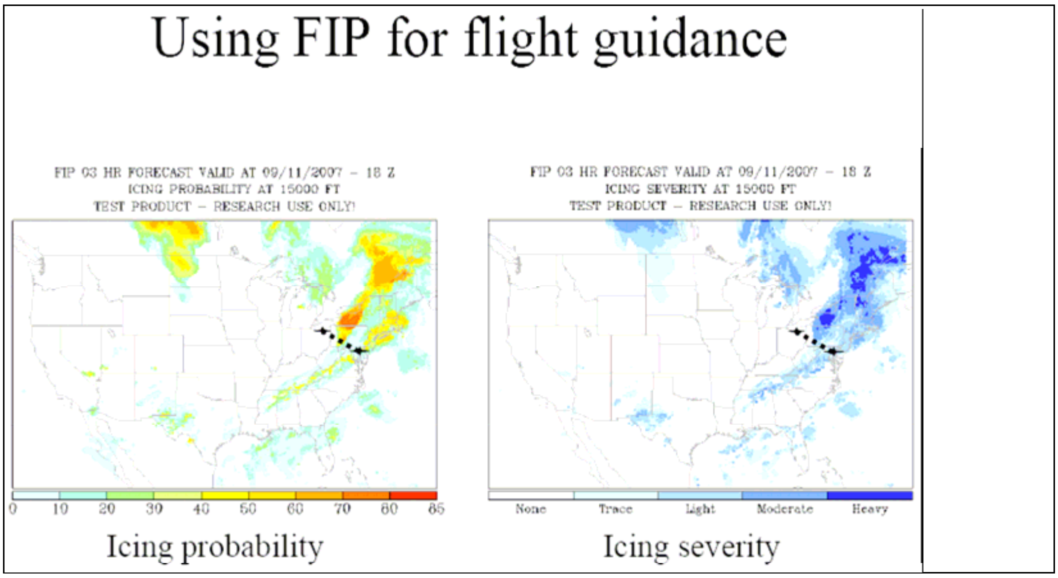
- Map cloud data to icing interest values
  - -1 (negative) to 1 (very high)

•Retain maximum information throughout algorithm analysis

•Model uncertainties

- Deals conflicting data




Using FIP for flight guidance
FIP 03 HR FORECAST VALID AT 09/11/2007 – 18 Z
ICING PROBABILITY AT 15000 FT
TEST PRODUCT – RESEARCH USE ONLY!
0 10 20 30 40 50 60 70 80 85
Icing probability
FIP 03 HR FORECAST VALID AT 09/11/2007 – 18 Z
ICING SEVERITY AT 15000 FT
TEST PRODUCT – RESEARCH USE ONLY!
None Trace Light Moderate Heavy
Icing severity

附件四 模式更新簡報資料

AOAWS–ES Modeling Update and Plans

Dr. Jordan G. Powers

Mesoscale and Microscale Meteorology Division

Earth & Sun Systems Laboratory

National Center for Atmospheric Research

Boulder, Colorado, USA

NCAR–CAA AOAWS Project Fall 2008 Meeting

October 14, 2008

IA11 (FY08) Modeling Task Status

- **Assistance to maintain the operational WRF model**

  1) Troubleshooting problems through the year
     - Repair to Kain-Fritsch scheme (May 2008) (compiler option O2 v. O3)
     - Modified Goddard scheme to eliminate unnecessary output
     - Made revisions to accommodate changes in WRF output directories at CWB
     - Work for switching of AOAWS-ES WRF to HPC backup machine

  2) Visits of MMM personnel (Dr. Bresch) to CWB for system development and support
     - May–June 2008 & October 2008

IA11 Modeling Task Status

- **Upgrade of WRF and WRF-Var**

1) WRF Version 2.2.1 implemented

2) WRF-Var Version 2.2 implemented

3) Recommendations provided to CWB on WRF and WRF-Var configurations

IA11 Modeling Task Status

- **Data assimilation: Satellite radiance data analysis**

1) Assimilation of AMSU-A radiance data tested in East Asia CAA domain

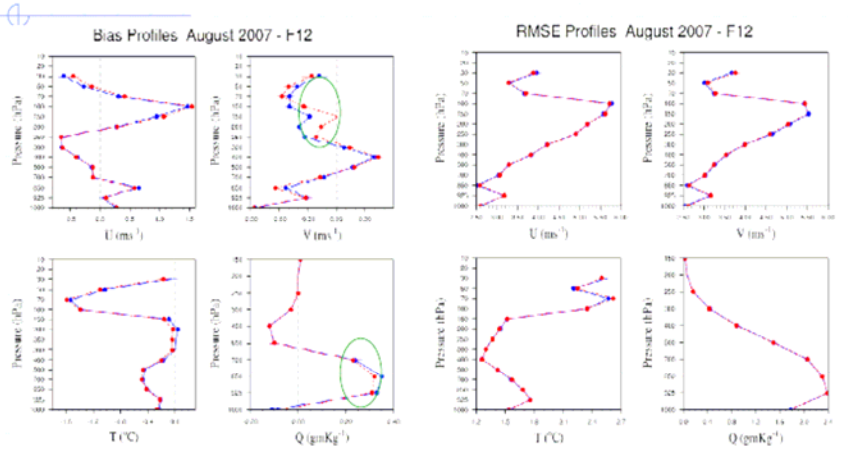
AMSU-A= Advanced Microwave Sounding Unit– A

2) Positive impacts found from radiances

AMSU-A Radiance Data Assimilation Study

- WRF & WRF-Var V3.0
- 45-km CAA Domain 1
- Experiments for August 2007
  - GTS: Assimilated CWB GTS data every 6hr
  - GTS + AMSUA_SEA: Assimilated CWB GTS + AMSU-A data over ocean

Bias and RMSE: 12-hr Forecast v. Observations



Test Case: Typhoon Sepat (2007)

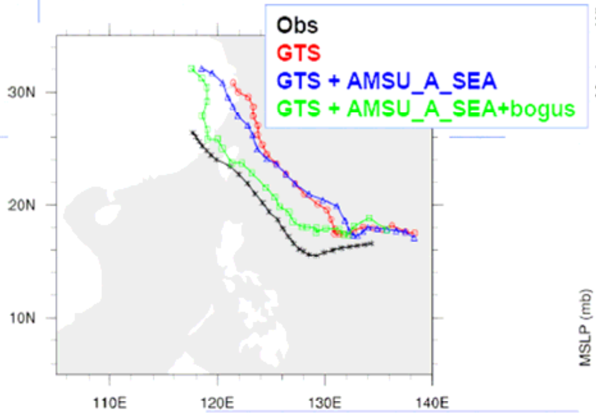
2007 08 12 06Z: Trop Storm
2007 08 13 18Z: Typhoon
2007 08 15 00Z: Supertyphoon
2007 08 17 06Z: Typhoon
2007 08 17 21Z: Landfall
2007 08 19 00Z: Trop Storm

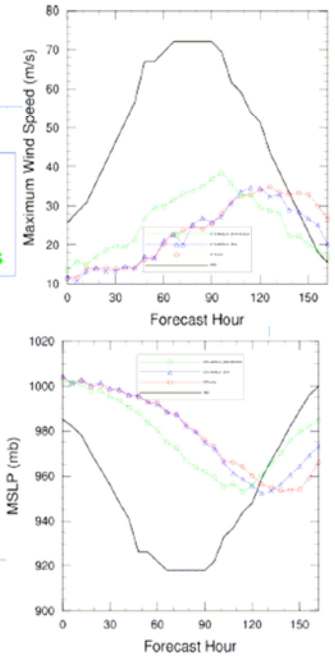
- 6-hr cycling runs 08/11 0000Z– 08/19 1800Z
  - GTS: GTS data assimilated
  - GTS+AMSUA_sea: GTS data plus AMSU-A radiance data over ocean
  - GTS+AMSUA_sea+bogus: GTS, AMSU-A data over ocean, and bogus vortex observations
  - AMSUA_sea: AMSU-A data over ocean only
  - AMSUA: AMSU-A data over ocean and land
- 72-hr forecasts, 00Z and 12Z inits

0225 UTC
16 Aug 2007

Forecasts initialized at 8/13/07 00 UTC

Period: 8/13 00 UTC– 8/19 18 UTC





IA12 Main Modeling Tasks (FY09)

- *Evaluate WRF precipitation forecasts and test cumulus and microphysics schemes*
- *Operational support to CWB for WRF modeling system and tests with new WRF grids*
- *Maintain (i) model display and (ii) model verification systems*
- *Assist in configuration and implementation of WRF-Var and new data types*
- *Assist with icing & turbulence product tuning*

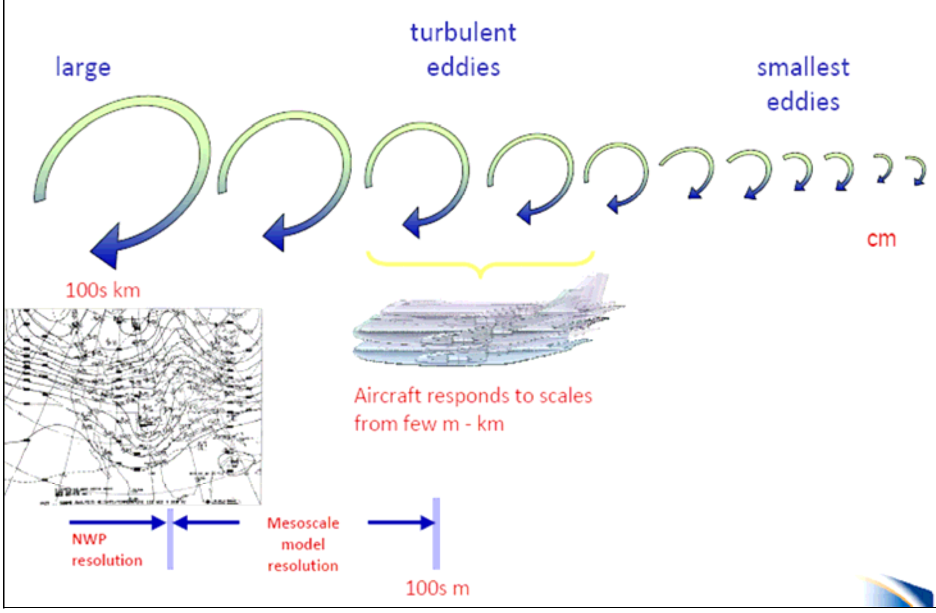
附件五 亂流校驗簡報資料

Background: Safety/cost Motivations

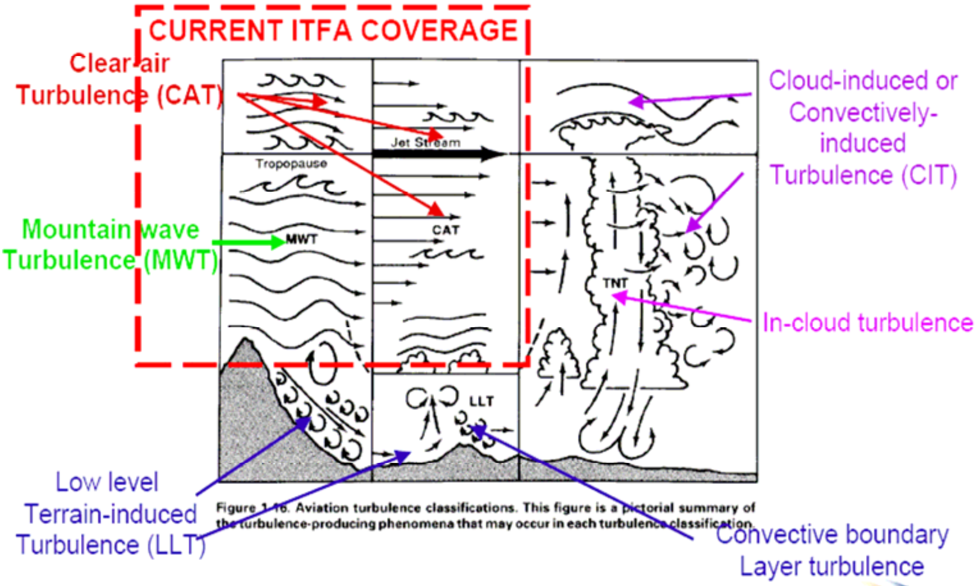
- Turbulence is a significant safety issue
  - CAST analysis (1983-1999) of NTSB "accident" data
    - ~70% of weather related injuries
    - 3 fatalities,176 serious, 544 minor injuries
  - Independent MCR Federal study of NTSB data 1983-1997
    - 665 cited turbulence as a cause or factor
      - 1,438 injuries
      - 609 fatalities (mainly GA)
  - Cost to airlines ~ $30M-$60M/year
  - Costs incl. GA and air taxi ~ $185M/year
- Contributes to public perception that air travel is unsafe
  - Severe encounters (PIREPS) ~ 5,500/year
  - Actual numbers probably much higher…
- Also a capacity issue…

2008/12/23

Background - Scales of aircraft turbulence



Background – known turbulence sources



Source: P. Lester, "Turbulence – A new perspective for pilots," Jeppesen, 1994

NCAR

Turbulence Forecasting

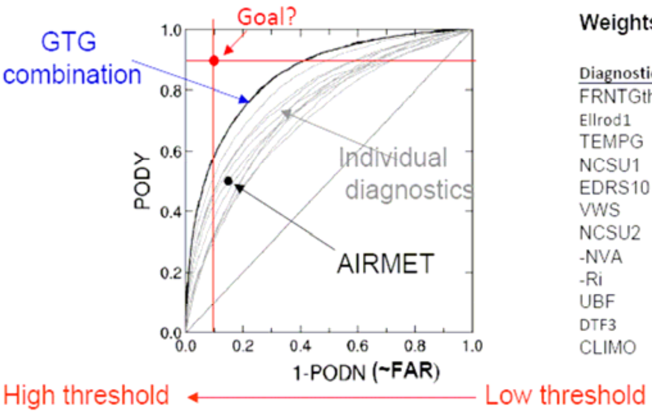
- Cannot directly predict aircraft scale turbulence
  - 5000kmX5000kmX25km CONUS domain @ 25m resolution = $2x10^5$ X $2x10^5$ X 10^3 = 40,000 Gigawords/variable!!
- Only hope is to infer turbulence potential from larger scale
  - Environmental observations/forecasts (NWP model)
  - Available turbulence measurements (PIREPs, insitu EDR)
- Multiple causes require multiple forecasting strategies →
- ITFA (Integrated Turbulence Forecasting Algorithm)/ Graphical Turbulence Guidance Product (GTG)
  - Based on RUC/WRF NWP forecasts
  - Uses a combination of turbulence diagnostics, merged and weighted according to current performance (pireps, EDR)

$$ITFA = W_1D_1^* + W_2D_2^* + W_3D_3^* + \ldots$$

ITFA/GTG History

- Forecasting system originally named ITFA (Integrated Turbulence Forecasting Algorithm)
- FAA versions
  - Based on RUC NWP model
  - FAA version renamed Graphical Turbulence Guidance (GTG) in 2002
  - GTG1
    - Upper-level CAT (FL200-FL450)
    - Operational on ADDS since 3/2003
    - http://adds.aviationweather.noaa.gov
  - GTG2
    - Clear-air sources 10,000 ft MSL-FL450
    - On Experimental ADDS since 11/2004
    - http://weather.aero/
    - Will replace GTG1 on operational ADDS Mar 2009
- Previous CAA version
  - Similar to GTG1
  - Based on MM5 NWP model
  - Implemented end of 2001

Sample GTG2 Statistical Performance (MOG vs NULL): ROC curve metric



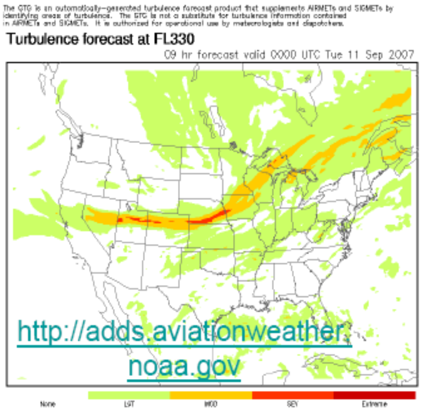
Weights ~ AUC²

Diagnostic	Weight
FRNTGth	0.703
Ellrod1	0.669
TEMPG	0.622
NCSU1	0.612
EDRS10	0.592
VWS	0.583
NCSU2	0.567
-NVA	0.556
-Ri	0.552
UBF	0.542
DTF3	0.538
CLIMO	0.469

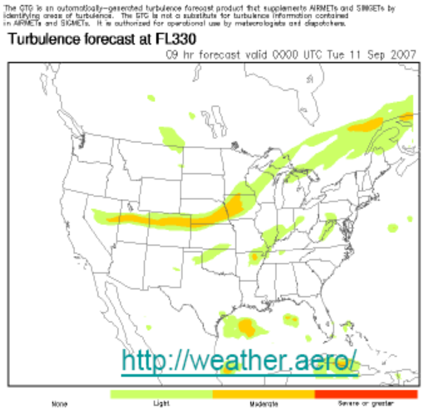
Individual diagnostics and the GTG2 PODY-PODN performance statistics (individual diagnostics as thin grey, GTG combination using dynamic weights as heavy black solid and GTG combination using climatological weights as heavy black dashed) derived from one year (2003) of 18 UTC 6-hour forecasts (valid 00 UTC) using 49,703 PIREPs, for upper-levels (FL200-FL460). For comparison, also shown is the no skill line as the diagonal, and the 2003 average AIRMET performance (with amendments) at upper-levels centered on 00 UTC.

GTG1 vs. GTG2

GTG1



GTG2



GTG3/Taiwan ITFA

- Version A
  - Improved CAT, MWT diagnostics
  - Based on RUC13
  - Probabilistic output
  - Initial implementation (exp. ADDS) in early 2009
- Version B: Similar to version A except
  - Based on AR WRF
  - Still under development/testing
  - Snapshot in late 2007 became Taiwan ITFA
- Since then…
  - Turbulence diagnostics made more consistent with WRF coordinate system
  - Intercomparisons of WRF vs RUC compared to PIREPS
  - Will implement in the FAA and Taiwan versions early next year
  - Note: Will share the same computational core

Projected GTG releases – next 7 years

Version	Capabilities	Op. date
GTG1	Upper levels RUC20	3/2003
GTG2	Improved GTG1 Mid levels Uses in situ	????
GTG3a	Improved GTG2 MWT Probabilistic forecasts Optimized insitu	FY09
GTG3b	13 km WRF RR (pre-impl 08, final early 10)	FY10
GTG4	Improved GTG3 out-of-cloud turb forecasts	FY11
GTGN1	NTDA2/DCIT in situ GTG4 > 10,000 ft	FY11
		NextGen IOC
GTG5	Improved GTG4 Low levels	FY13
GTGN2	NTDA2 GTG5 all altitudes	FY14
GTG6	Improved GTG5 Floating high res grids	FY16
GTG/TFO?	Global – GFS based	FY16

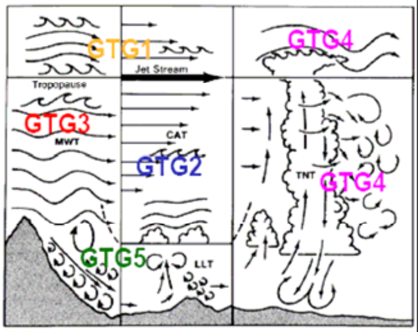


Figure 1-16. Aviation turbulence classifications. This figure is a pictorial summary of the turbulence-producing phenomena that may occur in each turbulence classification.

Source: P. Lester, "Turbulence – A new perspective for pilots," Jeppesen, 1994

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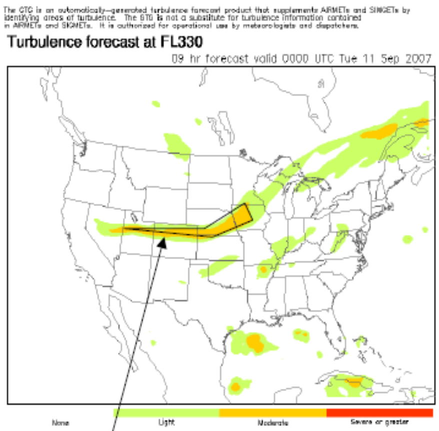
Current/future FAA GTG work areas

- Insure ITFA core supports all NWP models (RUC, ARWRF, GFS)
- R&D new turbulence diagnostics
  - MWT
  - CIT
  - Low levels
- Determine probabilistic performance of ensemble indices approach
- Develop polygon generator

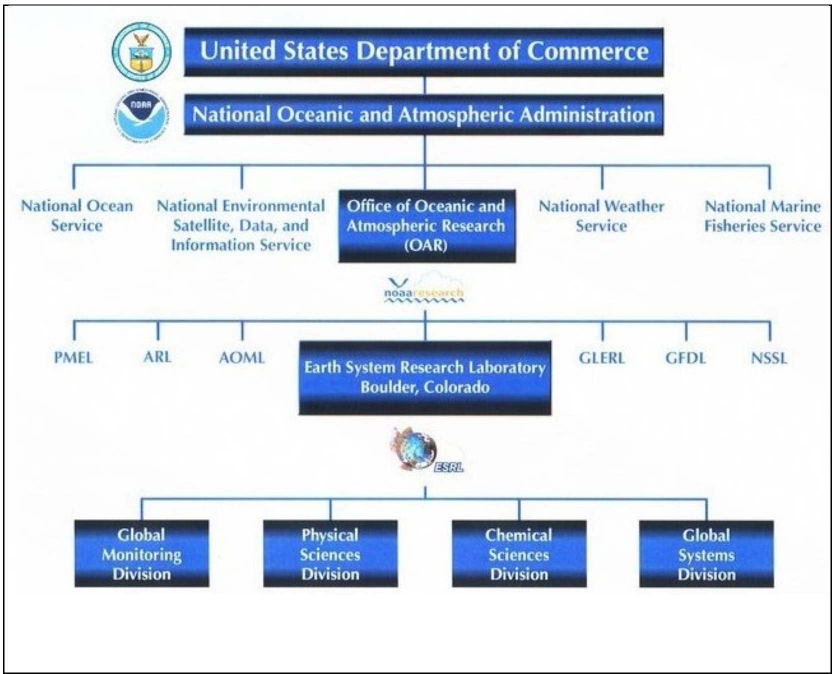


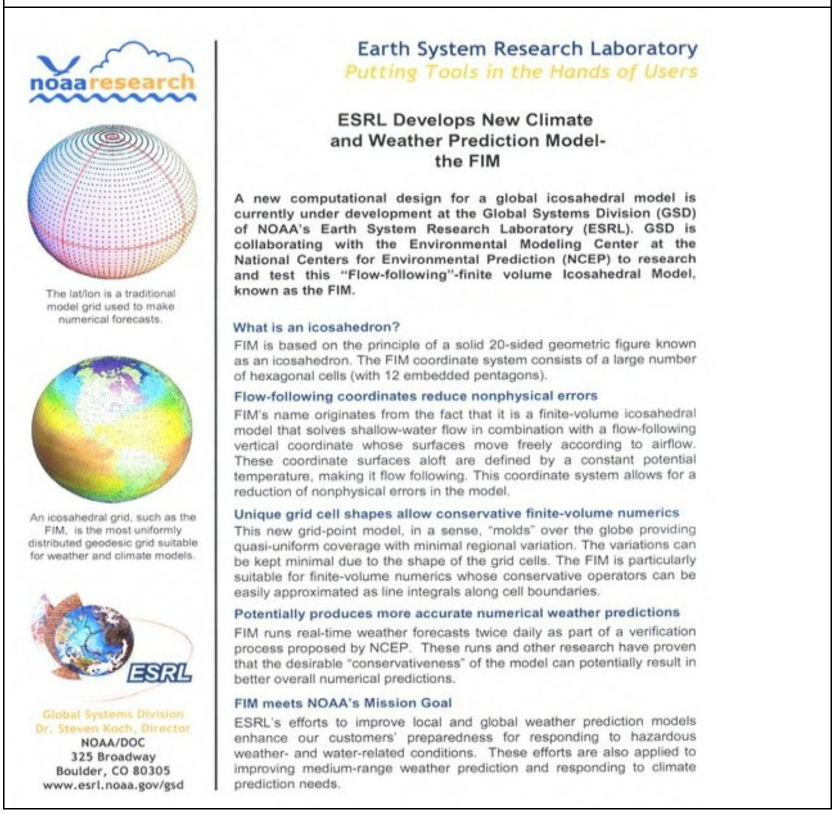
3D polygon fit to contours

附件六 協調會議討論紀錄

1. AOAWS 7.1 版本現況(Aaron):NCAR 已於 10 月中旬依民航局總臺的建議，安裝驗收前版本，目前雷達警示功能、機場天氣圖示功能、WAFS BUFR 資料顯示功能皆可在此新的版本中使用。
2. 檢視 IA#11 提交文件:NCAR 已準時提交第一季季報、第二季季報、第三季季報及驗收計畫草案，另外積冰產品校驗報告、亂流產品校驗報告已經完成，將待最後的文稿完成即可交付。第四季季報和交付軟體則於 12 月驗收會議之前交付。
3. 討論 IA#11 關於 WRF 模式組態改變之相關工作，由 NCAR 協調中央氣象局函送相關模式進度資料予民航局，以利驗收。
4. 檢視 IA#11 交付文件中相關工作的進行皆已順利完成。
5. 安排驗收會議之日期，初步達成共識於 12 月 4 日舉行。
6. 關於 AISS ftp Server 的建置，係配合民航局建置 AISS 系統，且未來將成為提供予航管系統的終端設施，NCAR 瞭解此項工作之重要性，並擬於 IA#12 的上半年完成。

附件七 NOAA 地球系統研究實驗室簡介





noaaresearch

Earth System Research Laboratory

Putting Tools in the Hands of Users

ESRL Develops New Climate and Weather Prediction Model- the FIM

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

What is an icosahedron?

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

Flow-following coordinates reduce nonphysical errors

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

Unique grid cell shapes allow conservative finite-volume numerics

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

Potentially produces more accurate numerical weather predictions

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

FIM meets NOAA's Mission Goal

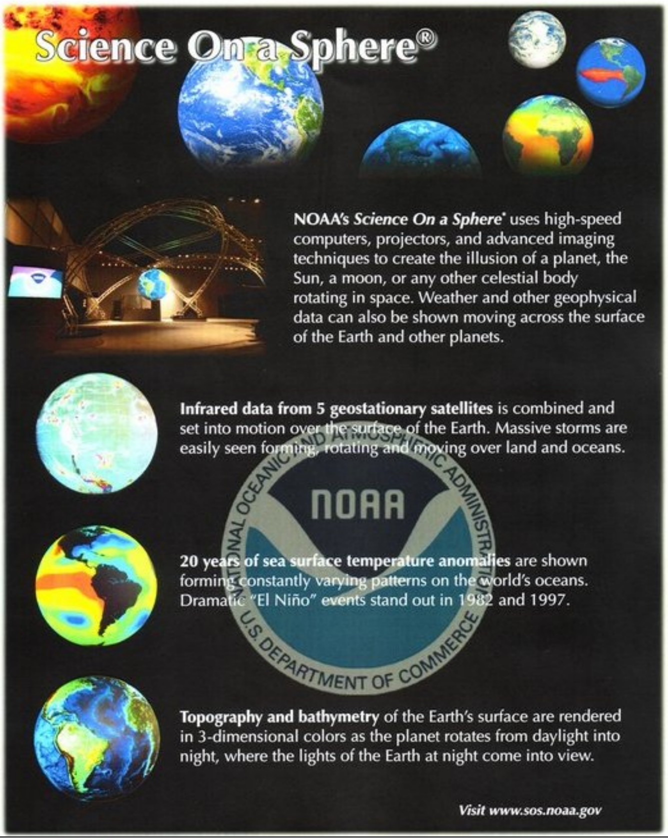
ESRL's efforts to improve local and global weather prediction models enhance our customers' preparedness for responding to hazardous weather- and water-related conditions. These efforts are also applied to improving medium-range weather prediction and responding to climate prediction needs.

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

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

ESRL

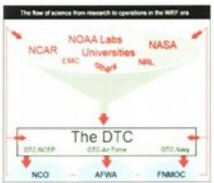
Global Systems Division
Dr. Steven Koch, Director
NOAA/DOC
325 Broadway
Boulder, CO 80305
www.esrl.noaa.gov/gsd



DTC THE DEVELOPMENTAL TESTBED CENTER (DTC)

Who are we?

The Developmental Testbed Center is a facility where the Numerical Weather Prediction (NWP) research and operational communities interact to accelerate testing and evaluation of new models and techniques for research applications and operational implementation, without interfering with current operations. The DTC is a joint operation between the National Center for Atmospheric Research (NCAR) and the NOAA Earth Systems Research Laboratory (ESRL) in Boulder, CO.

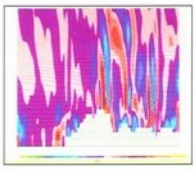


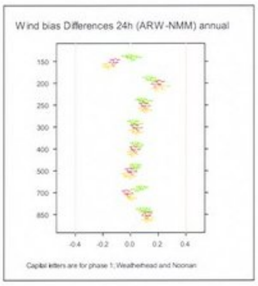
Why do we need a DTC?

- In the US, the transfer of new NWP science and technology from research into operations needs to be streamlined.
  - Primarily conducted at the operational centers or their associated research organizations
  - Does not take advantage of the considerable talent elsewhere in the research community
- Research and operations NWP communities have insufficient opportunities to collaborate in an operations-like environment.
- Research and operations communities do not have a facility to jointly perform extensive rigorous model testing using a common model and operational data stream without disrupting operations.
- NOAA will use the DTC as the primary gateway through which promising well-tested NWP science and technology originating in the research community will be selected for further development and evaluation by the National Centers for Environmental Prediction (NCEP).

DTC's Goals are to:

- Link research and operational communities
- Speed transition of research results into operations
- Accelerate improvement in weather forecasts
- Develop and test promising new NWP techniques
- Provide an opportunity for NWP community to perform cycled or real-time tests of model and data assimilation systems





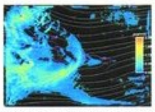
What is the DTC doing currently?

- The DTC just completed the WRF (Weather Research and Forecasting) model "Core Test" to determine the impact of the two WRF dynamic cores - the Nonhydrostatic Mesoscale Model (NMM) developed by NCEP and the Advanced Research WRF (WRF) developed by NCAR - on model forecasts using the exact same physics, initial, and boundary conditions.
- This evaluation will be instrumental in NCEP's decision about which core to adopt for the future WRF Rapid Refresh model to replace the current operational Rapid Update Cycle model.
- The DTC also conducts biannual tutorials on the WRF-NMM model for the community.
- The DTC is establishing an ongoing system for maintaining and supporting WRF Reference Code to the community.
- Work is ongoing with the NMM and ARW models run at very high (2-km) resolution to examine their ability to properly simulate the structure and dynamics of mountain waves observed by special field instrumentation during the Terrain-Induced Rotors Experiment (T-REX) in the Sierras.

Earth System Research Laboratory

Integrating Research and Technology

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



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

South Pole Observatory

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

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What does the Earth System Research Laboratory do for the Nation?

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

Background

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

Recent Accomplishments:

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

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

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

Unmanned Aircraft Systems

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

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

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

What are Unmanned Aircraft Systems?

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

Unmanned aircraft can fill gaps in our current monitoring systems.

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