行政院所屬各機關因公出國人員出國報告書
(出國類別：協商)

赴美出席即時天氣預報系統合作計畫
協商會議報告

服務機關：交通部中央氣象局
出國人職稱：主任
姓名：申湘雄
出國地點：美國
出國期間：民國 89年10月18日至10月27日
報告日期：民國 90年 1月18日

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壹、協商會議目的

中央氣象局爲了提昇氣象資料處理與應用的技術能力和發展天氣整合與即時預報系統(Weather Integration and Nowcasting System；WINS)，自民國七十九年六月至今，已和美國商業部國家大氣與海洋總署下的預報系統實驗室，陸續簽署了十二個合作計畫執行協定，進行長期的系統合作發展與技術轉移工作事項。爲了確保合作計畫能於本局落實生根，特別安排於計畫合作期間內，每年有二至三人年本局人力派駐於美方，進行技術轉移及合作發展事項；又隨計畫之進行，每年安排二至四次技術人員短期交換互訪，進行技術交流與協商；此外，每年有二次計畫管理人員互訪，進行工作時程擬定及進度審核。本局並有任務編組，以長期進行系統合作開發及技術轉移事項。目前，本局第一階段的WINS系統已成功地發展完成，正在線上作業中。本局於第三期電腦化計畫中，所規劃的數値預報系統及WINS第二階段發展計畫，也已陸續上線作業。

由於本合作計畫已近尾聲，故雙方協議於八十九年度及九十年度分別於美國舉辦兩次、台灣舉辦一次計畫總檢討會議。本次會議除了展開評估本局與美方五年來合作計畫之各個細節外，也再次對第十二號工作執行協定的執行成果，與下年度氣象局-FSL之第13號執行協定 (IA#13)的合作項目，各項工作執行情形包括確認各項工作細節及人員安排報告等，進行了廣泛討論。另外，氣象局也對FSL的發展方向及未來可能合作項目提出討論。

此行參與了十五場會議，會晤了二十餘位FSL的同仁，其中包括了FSL的director，七個部門的主管，各項研究計畫的主持人，及主要的技術經理，廣泛討論美方目前最新的氣象資料處理技術及FSL未來的研究計畫，發展方向，與可能合作的議題，以作爲未來系統發展的參考。

貳、協商會議過程

本次與美預報系統實驗室(FSL)的協商與評審會議，在美國科羅拉多州的波德市舉行，本局參加的人員有氣象資訊中心申主任湘雄及本局派赴在美工作同仁，資策會參加的人員爲資策會氣象專案黎經理兆濱，美方參加的人員計有預報系統實驗室主任麥當勞博士(Dr. A.E. MacDonald)、國際計畫經理賓德爾博士(Dr. Bill Bendel)和美方FSL的各部門主管及主要計畫執行人員，共計二十餘人。整個計畫協商與評審議程於十月十九日開始舉行。

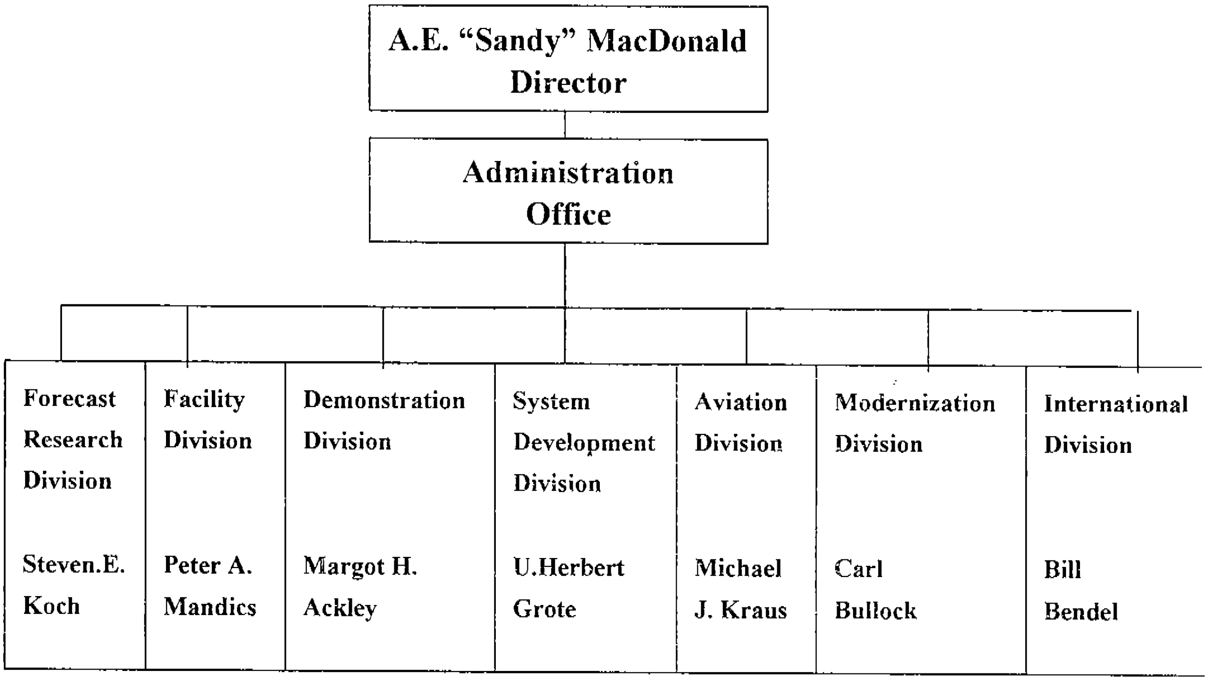
會議分三種型式進行，第一種型式之內容主要包括計畫總檢討，第十二號協定執行結果檢討，第十三號協定工作確認及未來合作內容與方式。參與的人員包括與我方合作之各部門主管、主要合作項目之負責人。

第二種型式則爲未來合作方式之探討，進行的方式則由職等分別拜訪FSL的七個部門的主管，瞭解各部門之目前之研發作業與未來的研發方向。

第三種型式爲問題解決，分別利用會議外之時間，將本局任務小組在台灣進行本土化移植作業上面臨之技術問題，與對方技術人員面對面溝通。

一、預報系統實驗室 (Forecast Systems Laboratory：FSL) 目前狀況

1. Forecast Systems Laboratory 組織架構圖



2. FSL 各部門介紹

FSL 爲 NOAA 所屬 ERL(Environmental Research Laboratories)中的一個大氣科學研究實驗室，下轄一個行政管理部門及七個作業部門。每個部門各自負責不同氣象預報領域的技術研發及實驗工作。下列各作業部門之研究計畫中以 * 標示的系統表示氣象局已經引進的系統、以 # 標示的系統表示氣象局有計畫引進的系統、以 $ 標示的系統表示氣象局有興趣交換經驗或引進的系統。

2.1 預報研究處(Forecast Research Division)

目標：短期預報及小尺度天氣現象之研究.

下轄三組：

區域分析與預測組
(Regional Analysis and Prediction Branch)

研究計畫

Mesoscale Analysis and Prediction System (MAPS)
Data Assimilation *
Numerical Prediction
Analysis and Model Verification
Data Sensitivity Studies
Well-Posed Model
Weather Research and Forecast (WRF) Model System $

小區域分析與預測組
(Local Analysis and Prediction Branch)

研究計畫

Local Analysis and Prediction System (LAPS) *
LAPS Observation Simulation System
Satellite Products
WFO Advanced Support
Three-Dimensional Variational Methods (3DVAR)*

氣象應用組
(Meteorological Application Branch)

研究計畫

Diagnostic Turbulence Forecasting
Quantitative Precipitation Forecasting
Global Air-ocean IN-situ System(GAINS Project)
Research Quality Datasets on CD-ROM and via the Web $
Websites for FSL Data $

2.2 設備處(Facility Division)

目標：Manage the computers ,communications and data networks, and associated peripherals that FSL staff use to accomplish their research and system-development mission.(請參閱附錄一)

2.3 展示處(Demonstration Division)

目 標：Evaluate promising new atmospheric observing technologies developed by the Office of Atmospheric Research laboratories and determine their value in the operational domain.

研究計畫

NOAA Profiler Network $ (請參閱附錄二)
Radio Acoustic Sounding System(RASS) for

Temperature Profiling

Boundary Layer Profilers

GPS Water Vapor Demonstration Network $(請參閱附錄二)

Alaska Profiler Network

2.4 系統發展處(System Development Division)

目標：Provide technical expertise in support of the laboratory's development of real-time meteorological workstations.

下轄三組：

先進展示系統組
(Advanced Display System Branch)

研究計畫

FX-Advanced (allow forecasters to display and interpret meteorological data) *

FX-Linux (porting FX-Advanced software to a linux platform) #

FX-3D (display multiple datasets in multiple windows to compare different forecast models concurrently.) #

FX-Connect (allow collaboration by multiple remote users in creating a manual forecast project.) #

資料蒐集與發送系統組
(Data Acquisition and Dissemination Systems Branch)

研究計畫

Local Data Acquisition and Dissemination (LDAD) $

科學應用組 (Scientific Applications Group)

研究計畫

AWIPS MAPS Surface Assimilation System (MSAS) $

Quality Control and Monitoring System $

2.5 航空處(Aviation Division)

目標：Improved weather forecasting and visualization capabilities for use by military and civilian forecasters , air traffic controllers and air traffic managers , airline dispatchers, and general aviation pilots.

下轄三組：

需求、應用與品質評定組
(Requirements, Applications, and Quality Assessment Branch)

研究計畫

Flight Planning Tools
Quality Assessment Tools
Product Generation and Grid Interaction Tools
U.S Air Force Weather Agency Project

航空系統發展與建置組
(Aviation Systems Development and Deployment Branch)

研究計畫

AWIPS/FX-Advanced and the Aviation Weather Center
Aviation Digital Data Service
Aviation Traffic Management System
U.S Air Force Weather Agency Project

先進計算組
(Advanced Computing Branch)

研究計畫

Scalable Modeling System (SMS) *

2.6 現代處(Modernization Division)

目標：Produce functional designs or working prototypes of techniques , workstations , and systems that may be implemented into National Weather Service.

下轄三組：

系統評估組 Risk Reduction Branch

Denver and Norman WSFO support and evaluation

預報工具強化組 Enhanced Forecaster Tools Branch

(AWIPS Forecast Preparation System)(IFPS)

研究計畫

Graphical Forecast Editor (GFE) *
Smart Tools #
Graphical Forecast Viewer (GFV) #
Rapid Prototype Project (RPP) #

先進技術發展組 Advanced development Branch

(AWIPS system evaluation and enhancement)

研究計畫

Emergency Management Decision Support $
AWIPS Development Support

2.7 國際處(International Division)

目標：Oversee internal development of systems intended primarily for global or international application and to facilitate international cooperative agreements and technology transfer programs.

研究計畫

The Globe Program $

The Joint Forecast System Project at the Taiwan Central Weather Bureau *

The FX-Net Project *(請參閱附錄三)

The Mount Washington Observatory Project

The Korean Meteorological Administration Project

The Tailand Meteorology Dept. Project

二、協商會議議程

主要會議於美國海洋暨大氣總署預報系統實驗室舉行，詳細議程如下：

AGENDA

FSL-CWB 2000 October Project Review Meeting

Thursday, October 19, 2000

- **10:00 a.m.**
  會晤 ：**Bill Bendel (International Division Chief)**
  議題 ：下期計畫合作方式

- **2:00 p.m.**
  會晤 ：**Wayne Fischer (International Division Deputy Director)**
  議題 ：目前 **International Division** 正在發展的 **project** 及 **FX-Net** 合作狀況

Friday, October 20, 2000

- **09:00 a.m.**
  會晤 ：**Denny Walts, Carl Bullock (Modernization Division Chief)**
  Herb Grote (System Development Division Chief)

議題 ：WFO-Advanced development
Status on FX-Advanced, FX-Linux and FX-Connect
Operational use of FX-Linux and FX-3D
FSL future role in AWIPS program

- 02:00 p.m.
  會晤 ：Rich Jesuroga, Patty Miller
  議題 ： LDAD development
  MSAS status and future plan

- 03:00 p.m.
  會晤 ：Mike Kraus (Aviation Division Chief)
  議題 ：AGFS Objective

- 04:00 p.m.
  會晤 ：Margot Ackley (Demonstration Division Chief)
  議題 ：NOAA Profiler and FPS-Met Systems

Monday, October 23, 2000

- 09:00 a.m.
  會晤 ：Jin-Luen and Ning Wang (FX-Net team member)
  議題 ：Wavelet compressing method

- 10:00 a.m.
  會晤 ：John McGinley (LAPS team manager)
  議題 ：LAPS development plan

- 11:00 a.m.
  會晤 ：Leslie Hart (HPCS team leader)
  Tom Henderson (HPCS team member)
  議題 ：SMS task status and FSL/HPCS future direction/plan

- 2:00 p.m.

會晤 ：Renate Brummer (leader of FX-Net team)
議題 ：FX-NET development, current status and future plan

- 3:00 p.m.
  會晤 ：Steven Koch (Forecast Research Division chief)
  Peter Mandics (Facility Division chief)
  議題 ：Discussion of computer usages, network environments, security issues, and backup facilities.

Tuesday, October 24, 2000

- 09:00 a.m. (Formal Review Meeting)
  參與者：中方 – 申湘雄 、黎兆濱
  美方 - Bill Bendel (International Division Chief)
  Wayne Fischer (International Division Deputy Director)
  Fathune Moeng (International Division manager)
  Herb Grote (System Development Division Chief)
  Carl Bullock (Modernization Division Chief)
  Renate Brummer(leader of FX-Net team)
  Ning Wang (FX-Net team member)
  John McGinley (LAPS team manager)
  議題 ：Review current CWB project

- 02:00 p.m. (Formal Review Meeting)
  參與者：中方 - 申湘雄 、黎兆濱
  美方 - Bill Bendel (International Division Chief)
  Wayne Fischer (International Division Deputy Director)
  Fathune Moeng (International Division manager)
  Herb Grote (System Development Division Chief)
  Carl Bullock (Modernization Division Chief)
  Renate Brummer(leader of FX-Net team)
  Ning Wang (FX-Net team member)
  John McGinley (LAPS team manager)
  議題 ：Discuss next year CWB project

Friday, October 25, 2000

- 10:00 a.m.
  會晤 Tom Schlatter (Chief Scientist, FSL)
  議題 WRF Plan
- 11:00 a.m.
  會晤 Woody Roberts (Evaluation team manager)
  議題 RRV, AWIPS evaluation

- 02:00 p.m. (Formal Review Meeting)

參與者：中方 - 申湘雄 、黎兆濱
美方 - A.E. MacDonald (Director, FSL)
Tom Schlatter (Chief Scientist, FSL)
Bill Bendel (International Division Chief)
Herb Grote (System Development Division Chief)
Carl Bullock (Modernization Division Chief)
Steven Koch (Forecast Research Division Chief)
Fathune Moeng (International Division manager)
議題 ：CWB Next Phase Plan and future co-operations

參、 協商會議內容與重要結論

本次會議除了對過去計畫中人員運用展開評估外，也確定了三次總檢討的方式、時程、參與人員等細節，屬於籌備會議性質；其餘的會議主要內容與結論簡述於后：

1. FX-Advanced

CWB 目前已 porting 到 4.3 版本，除了 Product Maker 及 Warn Gen 還有問題，不能順利執行(請 FSL 儘快協助解決)，其他部分運作皆無問題，今年進度順利；至於 5.0 版本預計明年在 CWB 建置・.

Herb 與 Carl 說明有關 FX-advanced 未來發展的計畫

(1) 關於版本 5.x

a. 版本 5.0 目前正在進行系統測試

b. 5.2.1 與 5.2.2 將於明年討論其實際內容

c. 版本 5.x 的重大改變： 所有的 plot file ， satellite file， 及非 grid file 形式的資料，以新的 product file 的形式取代原來的 netcdf 格式，並提供 converter，可將 netcdf 檔案轉換成 product file 格式

(2) 關於版本 5.1.1

a. 完成發展,明年一月開始上線

b. 改變雷達產品顯示的方式，不需經過資料表格的定義

c. 所有的 zoom 功能都改善爲 high resolution zoom

d. 所有產品顯示都能更有效的嵌入正確的 scale

(3) 關於版本 5.1.2

a. 明年五月開始發展,10 月 delivery

b. 可取代 NEXRAD 雷達的 pop 顯示工作站

c. Generate hourly sounding base on grid data from model

d. IFPS 產生的 field 可導入 model

e. 更多類型的衛星產品

f. 產生像觀測資料的預報場

g. Satellite sounding

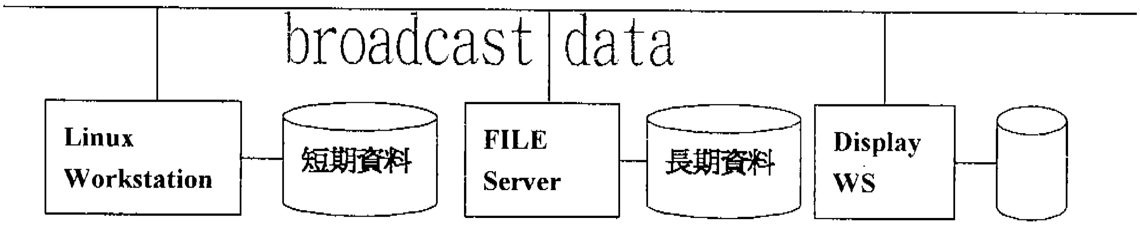
h. Observation data 轉成 grid field
i. Radar data 轉成 grid field

(4) FX-Linux porting

a. Porting 需考慮 software 在 HP 和 Linux 上皆可正確執行
b. 需解決的問題包括 graphic card，byte order，compiler
   C++(GCC) → gnu c compiler
   Fortran (g77) to → F90 compiler
c. 顯示部份已完成移植，Data acquisition software (例如 communication handling , decoding , reformatting , 和 text workstation)尚未移植

(5) 未來 FX-Linux 作業架構建議

Every system can pick up data, has its own database go through local access.



(6) FX-3D

a. Directory system 必須和 D2D 一樣
b. Similar "look and feel" as D2D capability
c. Allow D3D and D2D share the same database and the same accessors

(7) FX-Connect

a. Provides the basic capabilities to draw and edit lines, fronts, weather symbols, and annotate information on the top of meteorological displays.
b. The manual product can be saved locally and redisplayed or printed upon request
c. Allow collaboration by multiple remote users in creating a manual forecast product, user can join or disconnect from the session at will.
d. 本局可用於南部中心與北部中心預報討論溝通.

2. AFPS (AWIPS Forecast Preparation System)

本年度的工作項目之一，就是將 FSL 的 AFPS 系統進行本土化修改，作爲本局 FIES 系統的雛型版本，目前已完成的部分包括：

(1) Execute installation
(2) Execute make
(3) Run ifpInit

(4) Run ifpserver
(5) Run GFE
(6) Ingest NFS, LFS, MM5, 統計預報等四種模式
(7) 產生 T(溫度), RH(相對濕度), CI(舒適度指數), QPF 四種參數
(8) Read and display topography of East Asia
(9) Read and display coastline of East Asia
(10) Save data
(11) Minor change to GFE UI
(12) Modify ifpInit to deamon process and receive notification from LDM

本局的 FIES 系統經預報人員試用後有一些建議，另外，本局 FIES 發展小組在發展過程中也有一些疑問，這次 FSL 之行特別拜訪 TOM (AFPS team member)，澄清下列疑問：

問題(1)：目前資料的 lock 機制是以預報參數爲單位，兩個預報員不能同時編輯同一個參數不同時段的資料，如何處理?

回覆(1): lock = parameter + time period，兩個預報員同時編輯同一個參數不同時段的資料應該沒有問題。

問題(2): 預報人員要求編輯完成後可以簽名，以示負責。

回覆(2): 目前系統會將 login user name 與資料編輯完成的資料一同寫入資料庫，因 FSL 預報人員用不同 user name 登入該系統，所以可以根據此欄位區分出編輯資料的人，但該欄位在目前系統中並無任何作用，如果預報中心都用同一個 user name 登入，而要求在資料編輯完成後，另行簽名認證，目前系統無法做到，必須修改系統。

問題(3): 前一版的系統有 free hand tool，新版拿掉了，下個版本是否可放回來?

回覆(3): 因 FSL 預報員反應該工具不好用，所以拿掉，未來版本不可能放回，建議使用目前的工具，不要用 free hand tool.

問題(4): 目前系統只能輸出 image 檔案，可否考慮也輸出 contour plot ?

回覆(4): 下一個版本會輸出 contour plot.

問題(5): 目前系統提供多少種 formatter tools ?

回覆(5): pmg image format, text format, grib format, ascii grid format , netcdf format

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問題(6): GFV 在未來會繼續發展使用嗎 ?

回覆(6): 不會

問題(7): Python/C++/SWIG 三種語言使用時機?

回覆(7): C++ (for performance issue)

Python (user interface, smart tools, procedure, rapid prototype)

SWIG (Python call C++ class 或 C++ call Python 的介面語言)

問題(8): How to process model data if there are different time range for parameters in model?

回覆(8) : a. Redefine your parameter to 12-hour duration.

b. Initialize your parameter with 1/2 of the value from the model for each 12-hour grid.

c. When making products, recombine 2 12-hour forecasts into one 24-hour forecast by adding grid together.

問題(9): Which programs should be modified if the content of ParmID is changed?

回覆(9): No program should be changed

問題(10): 將 DFE 和 D2D 系統放在同一台機器上執行,D2D 的顏色會被影響?

回覆(10): 這是一個 bug，下一個版本會修正，但還是建議這兩個系統要放在同一部機器。

FIES 系統修改的過程中，本局工作小組曾多次發 email 詢問技術與設計上的問題，由於有些問題確實必須花費一些時間研究才有辦法作答，曠日廢時，特別利用這次討論下年度工作項目的機會，向 FSL 爭取明年度額外加派 IFPS

系統負責人之一 Tom 訪台一個星期，一方面對預報人員進行 GFE 編輯系統的操作訓練，一方面幫助 FIES 小組集中解答技術與設計上的問題，也獲得 FSL 方面的同意，相信這樣的安排，對 FIES 系統的設計與進度，會有很大的幫助。

3. FX-NET (Internet-Based FX Workstation)

FX-NET 是一個 internet-based 氣象 PC workstation，可將 FX-advanced 系統的產品，透過 internet 傳至 client 端的 workstation ，在 client 端提供一個與 FX-advanced workstation 相似的 user interface，顯示衛星、雷達、模式等各式產品。由於 FX-NET 在硬體價格上便宜很多，系統也比 FX-advanced 簡單很多，很適合用於預報員訓練、case 研究、與學術研究環境。FX-NET 盡可能具備 FX-advanced 所有顯示功能，缺點是 client 的速度稍慢與 resolution 較差，不過 Intel-based PC 進展迅速，問題將可大幅改善。

本局前兩年派兩位同仁參與 FX-NET client 端的建置，目前有一位同仁參與 server 端的研究，預計今年十二月該同仁回國後，可將 FX-NET 在 CWB 建置起來。

關於 FX-NET client 端說明如下:

(1) FX-NET client basic requirement
400MHz PC with 256 MB RAM
Windows NT/98,Linux
Bandwidth >= 56kbs

(2)Imitates the AWIPS User Interface

(3)功能包括 Load , Animation, Overlay / Toggle ,Zoom ,Swap

Compression Techniques for Product Representation

(1) Satellite - use Wavelet Transform
(2) Model Graphics and observations - DGM format (Dare graphics metarfile)
(3) Radar - GIF (lossless)

4. LAPS (Local Analysis and Prediction System)

本局去年派遣一位同仁到 FSL 一年技術轉移 LAPS 系統，回國後在 LAPS team 協助下在本局建立了 LAPS 系統，並開始上線運作，在 IA#12 名列的工作項目包括:

(1) Configure LAPS Grid
(2) Adapt LAPS for datasets
    a. SYNOP
    b. METAR
    c. buoy
    d. SHIP
    e. mesonet
    f. RAOB
(3) Adapt LAPS for model background
    a. CWB regional model
    b. FA mesomodel

至目前為止執行的工作成效包括:

(1) LAPS 軟體移植到 CWB
(2) 輸入 AMDP 接收的 SYNOP, METAR, buoy and SHIP 資料
(3) Mesonet data drivers written
(4) 開始雷達資料 ingest
(5) 本局 regional model as background
(6) FA model ingest 接近完成
(7) 開始自動作業並定時產出產品

下年度 IA#13 LAPS 工作項目包括:

(1) 增加區域中尺度觀測資料分析
(2) 預報員訓練
(3) 雷達資料 ingest
(4) 衛星資料 ingest
(5) 本局 WIAP

對於下一期計畫 LAPS team 提出的合作項目包括:

(1) FSL would like to work with CWB on high-resolution, local model applications
(2) FSL wants to exploit the water-in-all-phases product to be developed at CWB, to begin work on diabatic initialization procedures.
(3) FSL is developing a comprehensive analysis and modeling system with inexpensive LINUX PCs and would like to test this concept within the CWB.
(4) FSL will be an early use of WRF and can port this important development to CWB when the model is ready.

在這次會中我們對 LAPS team 提出下列建議:
(1) 除了 LAPS 建議的 datasets 外，本局認爲農業站與雨量站資料也是極有價值的 data sets，希望系統也能使用這兩種資料進行分析。
(2) 目前作業狀況，預報人員在兩小時以後才能看到 LAPS 產品，在時效上過慢，預報人員希望能愈早看到產品愈好，建議作業時間提前，或者執行兩次。

5. HPC (High Performance Computing)

(1) SMS plans
- Support for arrays with more than 3 dimensions
- Transfer interpolation (Second generation nesting support for TFS and other model)
- Fortran 90/95 support
- Dynamic load balancing
- Automatically generated directives
- Further I/O optimization
- Support for NetCDF
- New features as needed

(2) Potential Cooperation with CWB
- Next Procurement
- Cluster development support
- Work to support CWB in collaboration with national high performance computing center

6. CWB-FSL 合作計畫評估

(1) IA#12 工作內容與執行成果

工作內容

a. **SMS**
   -平行化氣象局的颱風模式
   -**SMS** 文件和使用支援
b. **FX-NET**
   -作業測試與系統評估
   -AWIPS server(HP platform), web server and client
c. **LAPS**
   -在氣象局建立 **LAPS basic system**
   -提供必要的教育訓練
d. 氣象局下期計畫規劃支援
   -工作項目建議與規劃支援
e. 對於先前合作系統的繼續支援
   -WFO-Advanced support
   .2000 年 **7** 月協助本局轉換至 **version 4.3**
   .2000 年 **8** 月 **release version 5.0**
   .2000 年 **8** 月 **7** 日**-11** 日**,FSL Mr. Woody** 和 **Ms. Patric** 對預報中心人員進行 **WINS II** 使用教育訓練
   -Deliver AFPS latest software

(2)IA#13 下年度合作計畫

A. Data Analysis (LAPS)

a. **Ingest of satellite data into cloud and surface analysis**
b. **NEXRAD radar ingest**
c. **Complete level III scheme**

B. Support on earlier project

a. **FX-NET participation**
b. **WFO-Advanced software release and support(FX, FX-Linux)**
c. **FIES support(one week workshop)**

7. 下期計畫合作內容與項目

(1) 下期計畫合作目標

a. Improve accuracy of short-term , small-scale severe storm warning or "nowcasting" capabilities.

b. Best utilize the CWB information systems, computing and communication
Infrastructure

c. Improve CWB dissemination service and its weather information network to support disaster management communities.

(2) 合作項目

a. Support CWB very short-range forecast
Implement an integrated VSRAF system utilizing appropriate technologies
-LAPS
-RRV (Regional Radar Volume)
-SCAN (System for Convection Analysis and Nowcasting)
. WDSS (Warning Decision Support System)
. AMBER (Area Mean Basin Estimated Rainfall)

b. Support information systems, computing and communication Infrastructure Information system
- D3D
- IFPS
- FX-Linux
- FX-Net
- FX-Connect
- LDAD quality control

. High performance computing and communication

(3) 合作方式

下期計畫 CWB 除了與 FSL 繼續合作外,還會透過 FSL 與 NSSL 合作.

8. FSL 提出總結性的摘要

(1) FSL 於 2000 年 9 月進行 technical review
(2) FSL 於 2000 年 10 月完成 IA#12 的工作項目與期末報告
(3) 由於政府會計年度的改變,#IA12 的執行期間由 12 個月延長至 18 個月,對 FSL 的預算影響頗大.
(4) IA#13 under a new umbrella agreement
(5) IA#13 只執行 6 個月
(6) FSL 在下期計畫的預算比這期計畫少(因有部分經費需轉給 NSSL)
(7) 下期計畫 CWB 與 FSL 簽約,再透過 FSL 與 NSSL 合作.

肆、心得與建議

本局與 **FSL** 合作將近十年，這十年來本局從 **FSL** 方面獲益良多，**FSL** 在氣象領域方面的知識與技術上的領先和持續的進步，是本局與其長期合作的主要因素。在合作的過程中本局之工作小組在資策會氣象專案小組的協助下快速而有效的進行技術轉移，並利用 **FSL** 系統架構與相關技術，配合本土化的條件，本局現有的資源與設備及預報人員特殊的需求，重新整合出一套本土化新的系統。雖然十年來，三方合作愉快，但在人力資源運用上建議希望在未來的合作計畫中有所改善，並獲得上級相關單位之大力支持：

1. 美國預報系統實驗室爲一先進氣象預報技術之研究單位，其宗旨在於研發各類先進技術並執行作業實驗，以便成功地將成熟之技術移轉給作業單位實際運用在預報作業上。

   該實驗室除了氣象背景人員外，也有大量之資訊背景人員，大部份之研發人員皆採用合約外聘，工作人員的上班方式完全採用彈性制度，以限期任務爲導向，工作效率相當高。

   因應工作之需求，必須經常採用資訊上之新產品，故與電腦廠商(軟、硬體)接觸頻繁，且經測試、實驗而能針對需求選取真正適用之軟硬體工具。

   以上諸點，皆非本局能採循之方式，故本局與其合作，尤其是派駐其單位之人員，除了貢獻自已的能力外，更能藉由其運作方式發揮更大的工作效能。除了實際合作發展項目外，另在新氣象科技、資訊技術、工作效率……等各方面，本局皆能藉此合作計畫獲益，彌補本局此方面之不足。

2. 本項計畫派駐國外人員，係參與一項國際合作計畫。計畫六年期間每年派遣人員參與發展及技術轉移之項目及時間，都經雙方詳細規劃安排，以在期限內達成任務爲唯一目標。

   派遣人員兼負發展、技術轉移(包括接受技術轉移及返國後擔任種子成員技術轉移給本局其他同仁)、學習、及計畫連繫、溝通之多重角色，任務繁重。

   計畫執行五年間，除第一年經費尚裕之外，往後皆因出國經費漸趨不足，而造成雙方困擾。建議上級單位往後核准本局此類合作計畫時能將計畫出國人員經費專案處理，不再併入本局一般出國費用，使合作雙方都能依原規劃順利執行任務。

3. 希望上級單位能重視此項合作計畫之實質效果而能多予支持。

附錄一

October 23, 2000

Current FSL Facility Division Projects/Activities

Peter A. Mandics

Central Facility

- FSL High-Performance Computing System (HPCS) integration into Central Facility (http://www-fd.fsl.noaa.gov/hpcs/)

- Networked Information Management client-Based User Service (NIMBUS) object-oriented upgrade

- Metadata Database (http://dorcas.fsl.noaa.gov:8080/)

- FSL Data Repository (FDR)

- Data acquisition/distribution
    - Replacement of leased lines with Internet (TCP/IP)
    - Unidata's Local Data Manager [LDM], NCEP's Distributed Brokered NETworking [DBNET])
    - Back up NCEP with RUC-2

Network

- FSL Asynchronous Transfer Mode (ATM)/Ethernet network upgrade

- Computer/network security - Dial in, VPN, SSH, firewall, etc.

FSL High-Performance Computer System (HPCS)

Contract signed: September 10, 1999

Vendor: High Performance Technologies, Inc. (HPTi)
Reston, Virginia

Compute Platform ($15M configuration)

Operating System: Linux - Red Hat 6.x for Alpha

Interconnect: 300 MB/s Myricom Myrinet

	Initial Nov. 99	Interim Nov 2000	Final Sept 2002
# Processors	256	512	1024
Type - Compaq Alpha	EV67	EV67	EV78
System Memory (GB)	128	256	640
Sustained Performance using SMS (GFLOPS/percent of peak)			
GFS	20/6	35/6	200/5
QNH	50/14		
QNHCONUS	50/14	80/15	400/10

FSL High-Performance Computer System (HPCS)

Mass Store System

Advanced Digital Information Corp. (ADIC) AML/J Robotic Library

Storage Management Software: ADIC's FileServ

AIT-2 cartridges - 50 GB native capacity

Sony AIT-2 drives - 6 MB/s transfer rate

	Initial	Upgrade	Final
Storage (1.33 comp)	100 TB	250 TB	250 TB

Storage Area Network

Data Direct Networks hardware

MountainGate Imaging Systems Corp. CentraVision File System (CVFS) software

Storage: 500 GB initial, 2 TB final

Direct connections to Compute Platform, MSS and 9 existing FSL platforms

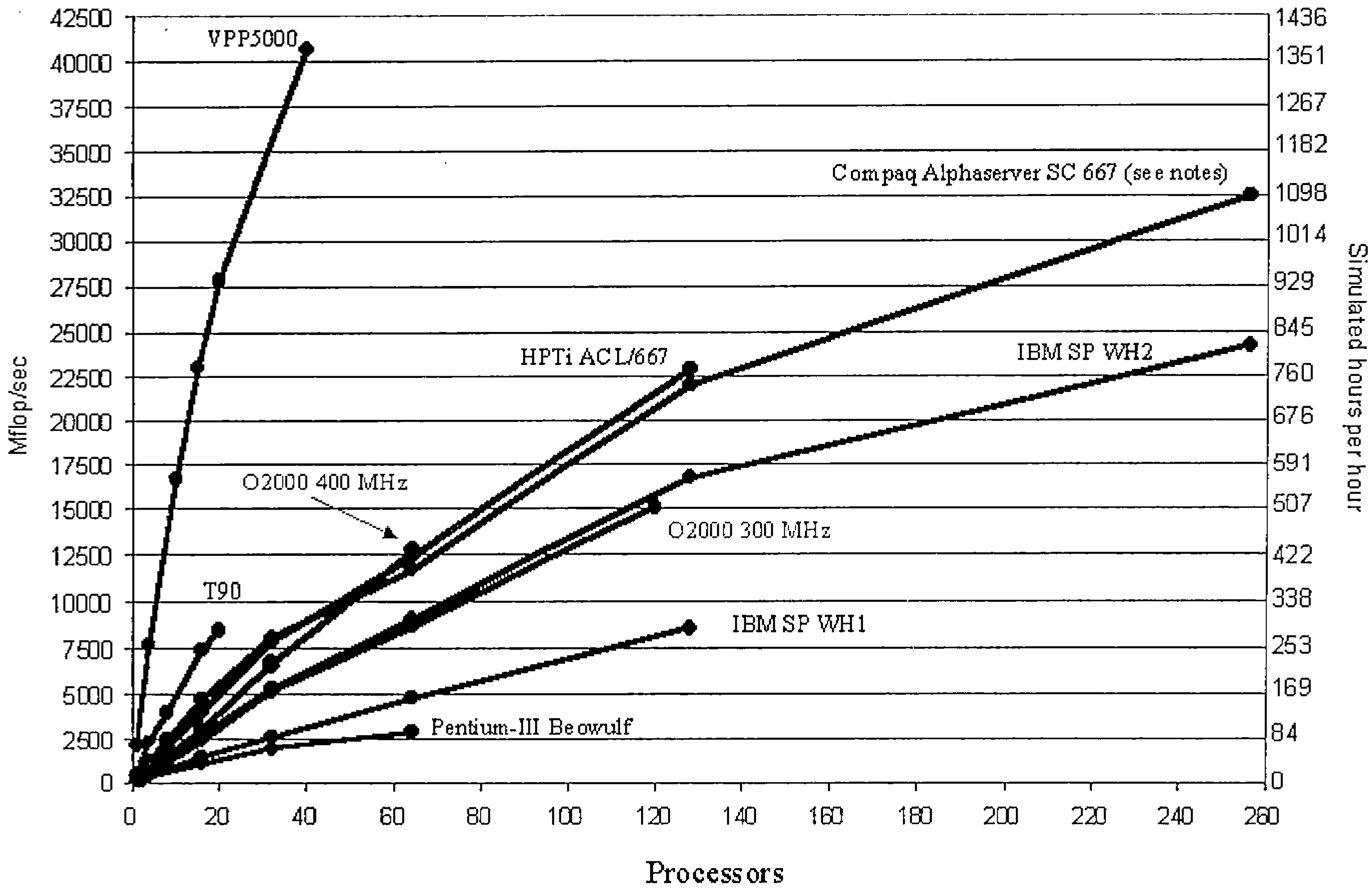
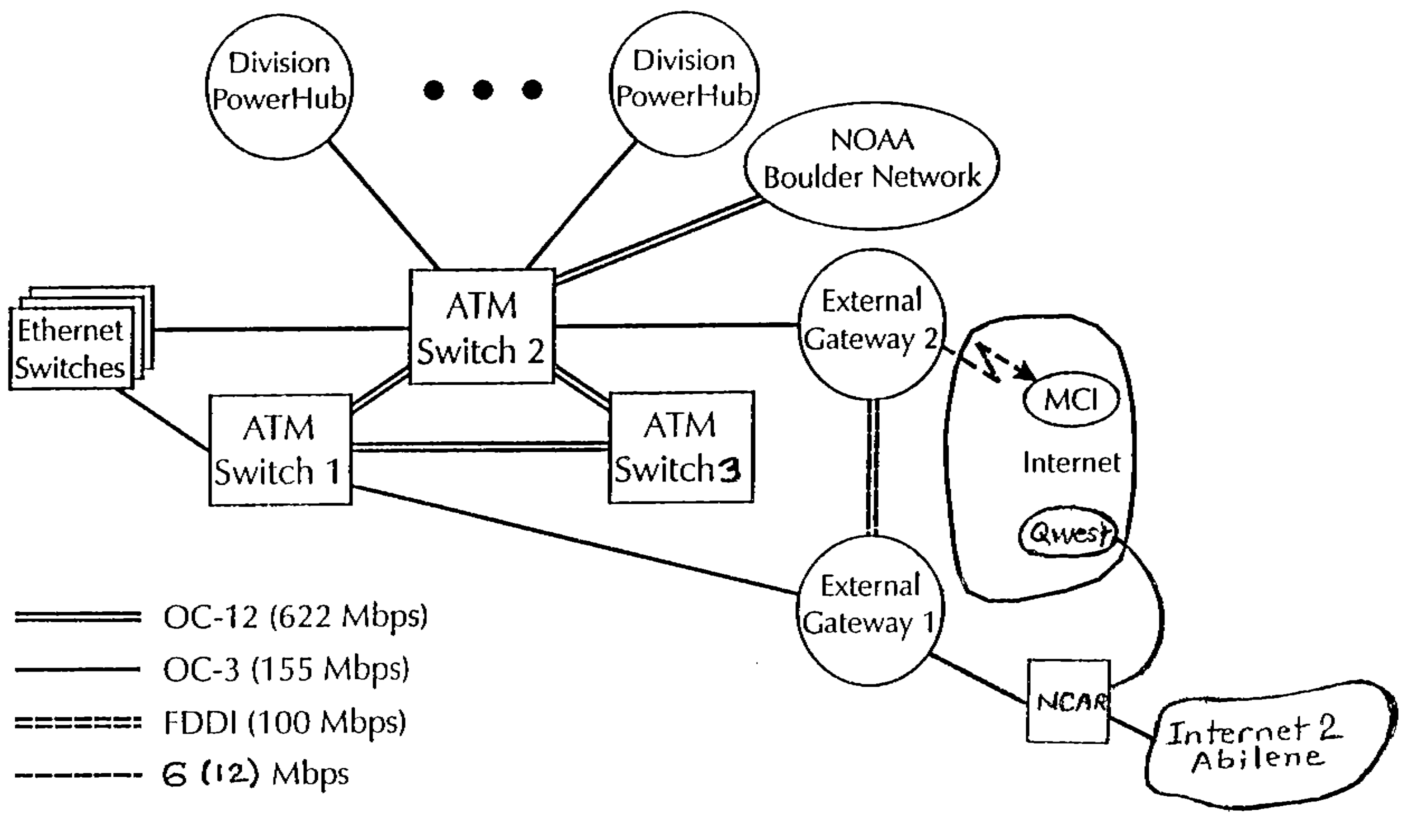


Figure 1. MM5 floating-point performance on various platforms.

FSL Network and Its External Connections



附 錄 二

NOAA Profiler and GPS-Met Systems

A Briefing for

Central Weather Bureau, Taiwan

October 20, 2000

Margot H. Ackley

Douglas W. van de Kamp

Seth I. Gutman

Demonstration Division

Forecast Systems Laboratory

Department of Commerce

Boulder, Colorado, USA

WIND PROFILER DEMONSTRATION PROGRAM

MISSION STATEMENT

To Develop, Deploy, and Operate

a Network of 30 Wind Profilers

in the Central United States

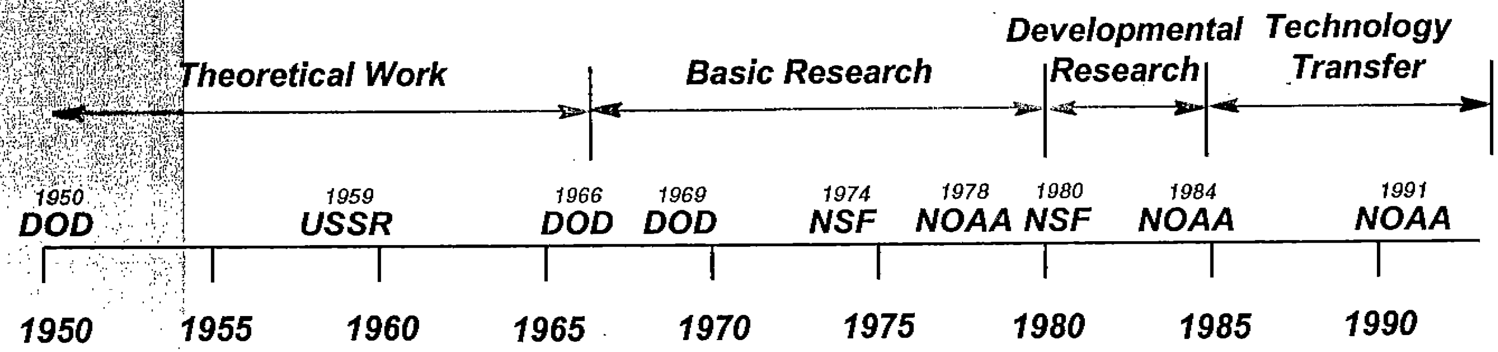
In Cooperation with NWS and Other

Agencies, and Conduct an Assessment

of that Network

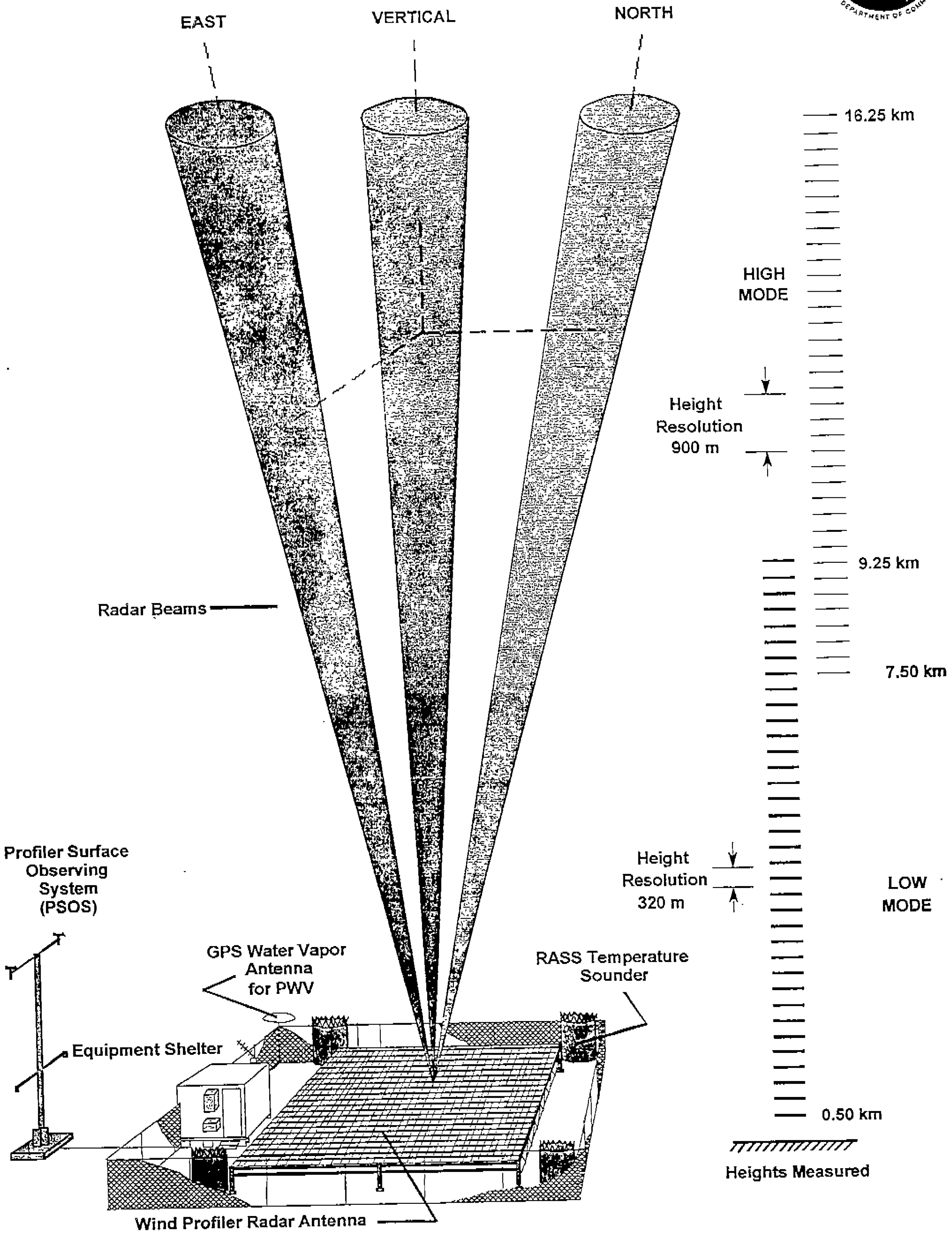
ratory

HISTORY OF PROFILER TECHNOLOGY

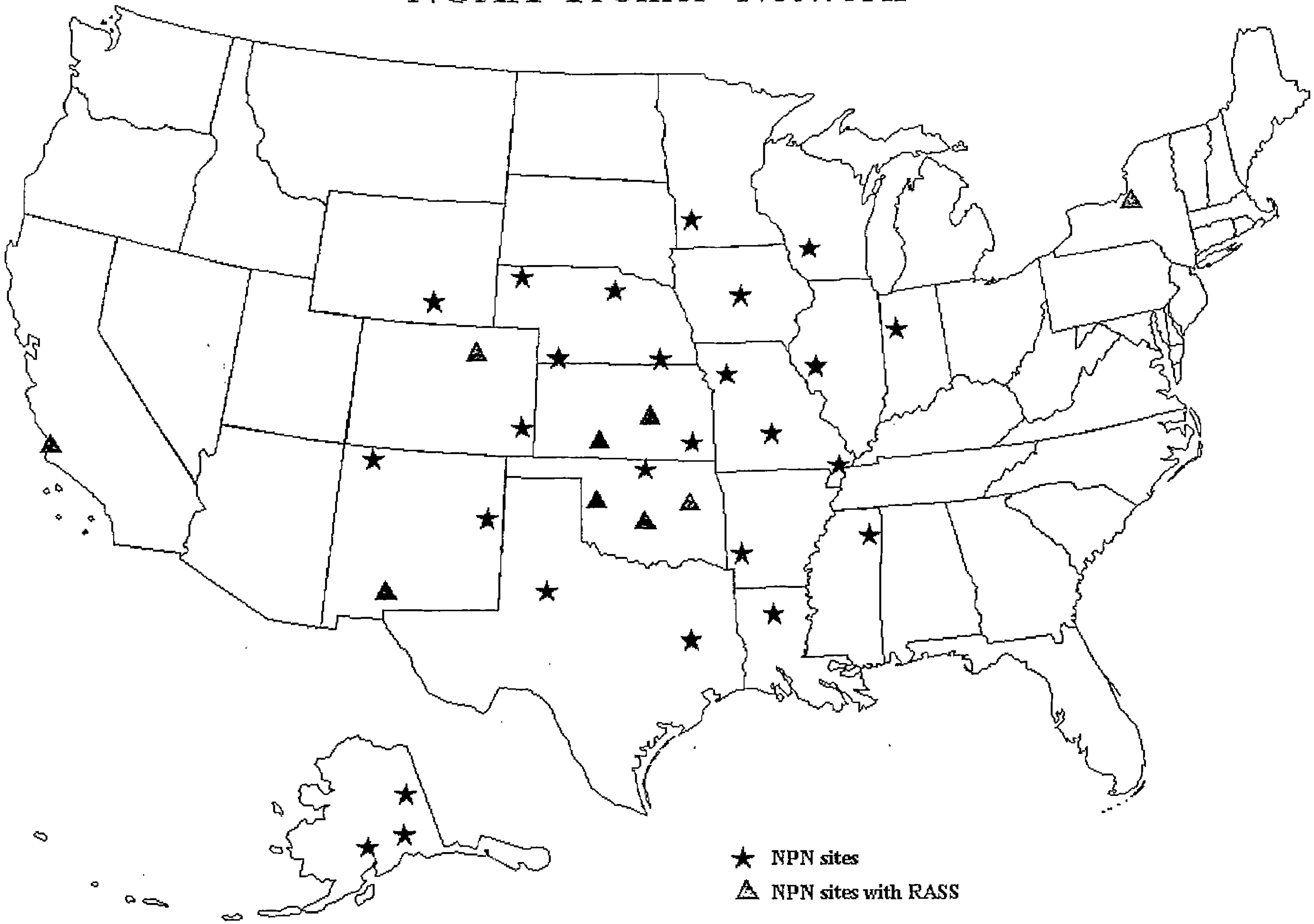


HISTORY1.WPG

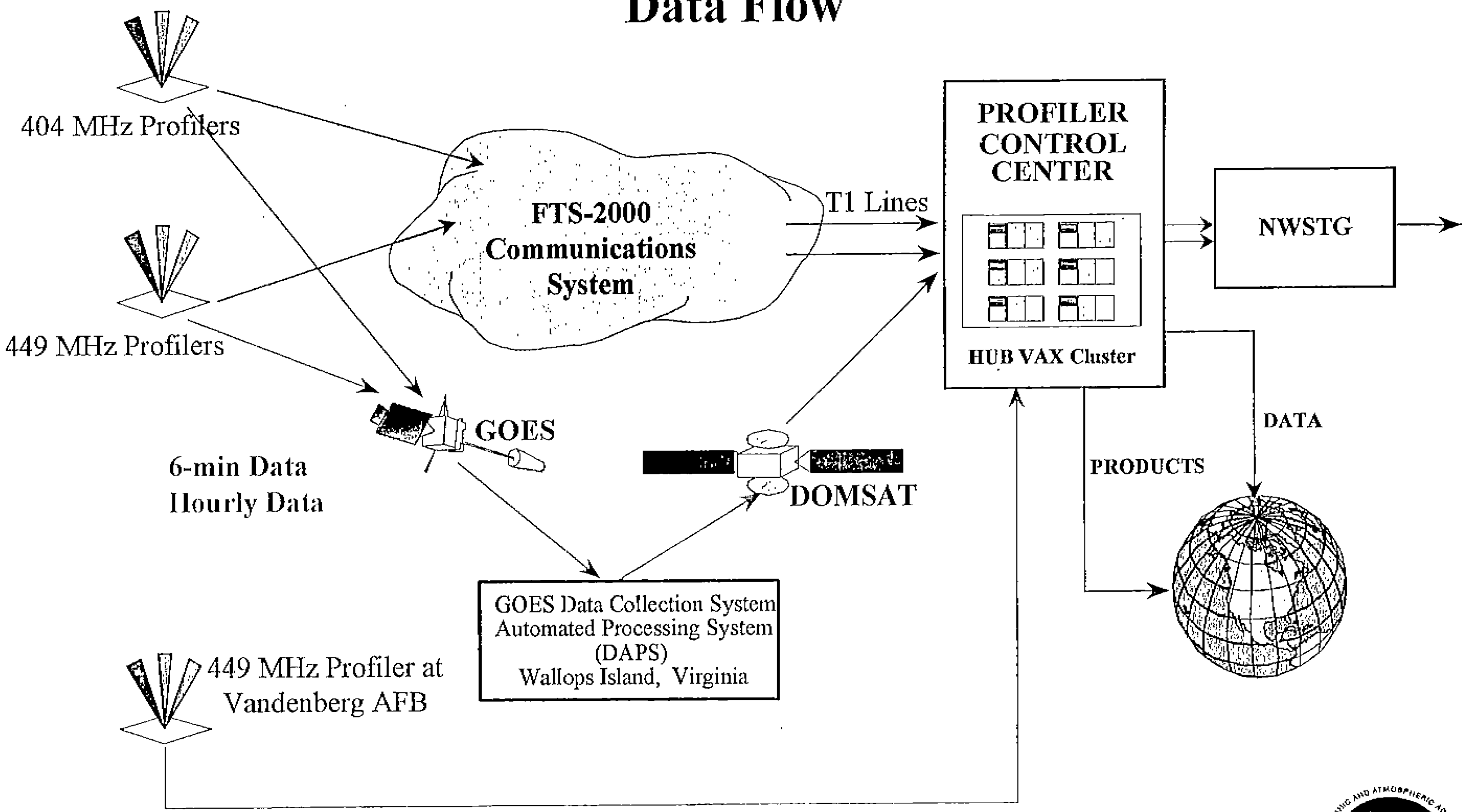
NOAA Profiler Network (NPN) Site Sketch



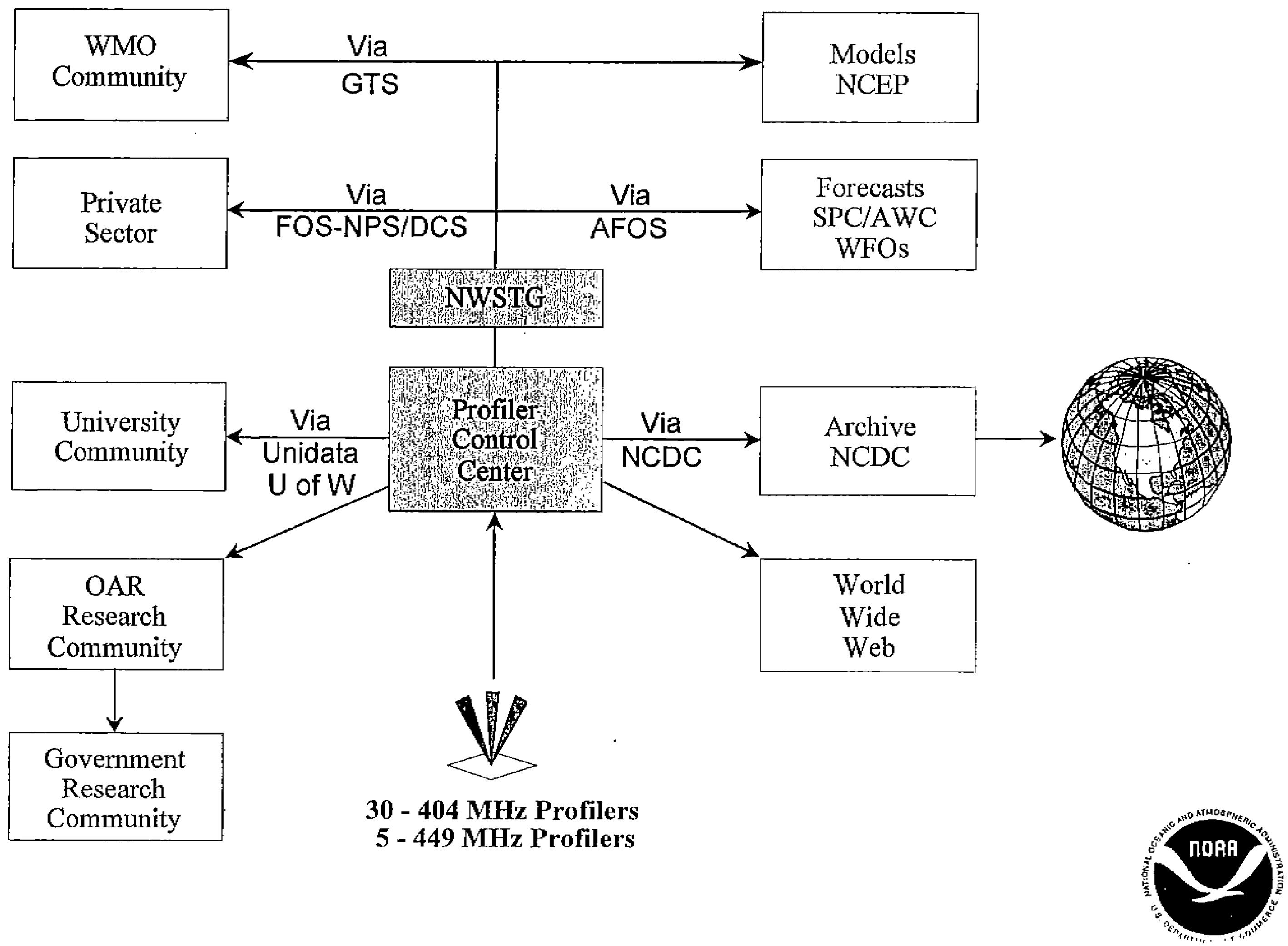
NOAA Profiler Network



National Oceanic and Atmospheric Administration
NOAA Profiler Network
Data Flow



Profiler Data Distribution



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BOULDER, COLORADO

Key Points

NOAA needs to improve its forecasts and warnings, especially of severe weather and precipitation. *Improved transportation safety depends on it.*

GPS can be used to make water vapor measurements that can help accomplish this goal.

Data from GPS deployed for improved positioning and navigation can be used for improved Wx forecasting at little or no additional cost.

Improved information about the atmosphere is needed for improved high accuracy positioning.

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Boulder, Colorado

Introduction

- An important goal in modern weather prediction is to improve short-term weather forecasts, especially of severe weather and precipitation, but…
- Our ability to do so is hindered by the lack of timely and accurate observations of atmospheric water vapor.
- The distribution of water vapor changes significantly in time and space, making it difficult to:
  - observe with conventional upper-air observing systems;
  - make accurate cloud and precipitation forecasts, especially under conditions of active weather.
- Improved surface and air transportation safety depends on improvements in weather forecast accuracy, especially in the range of 0-6 hours.

GPS In Weather Forecasting

- Most of the temporal variability in the GPS signal comes from water vapor in the lower atmosphere.
- This variability can be measured by COTS GPS receivers with very high accuracy under all weather conditions.
- In addition, GPS is low cost, reliable and easy to maintain. These factors make it a strong candidate as a next generation upper-air observing system.
- NOAA/FSL has demonstrated that the inclusion of GPS observations into NWP models improves forecast accuracy, especially during periods of active weather.
- The impact of GPS data is strongly correlated with the number of stations... not surprising. How best to increase the number of observations?

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GPS Meteorology

GPS Meteorology

Ground Based

Measures signal delay from fixed point on ground.

Integrated Precipitable Water Vapor

- Gives total precipitable water vapor directly above site
- Nearly ready for operational implementation

Slant-Path Signal Delay

- Gives line-of-sight signal delay to each satellite in view
- Concept demonstrated. Techniques under investigation

Space-Based Occultation

Measures signal delay from LEO satellites with near-global coverage

- Provides profiles of integrated refractive index (~ 1km x 300km)
- In development, highly leveraged, high implementation costs

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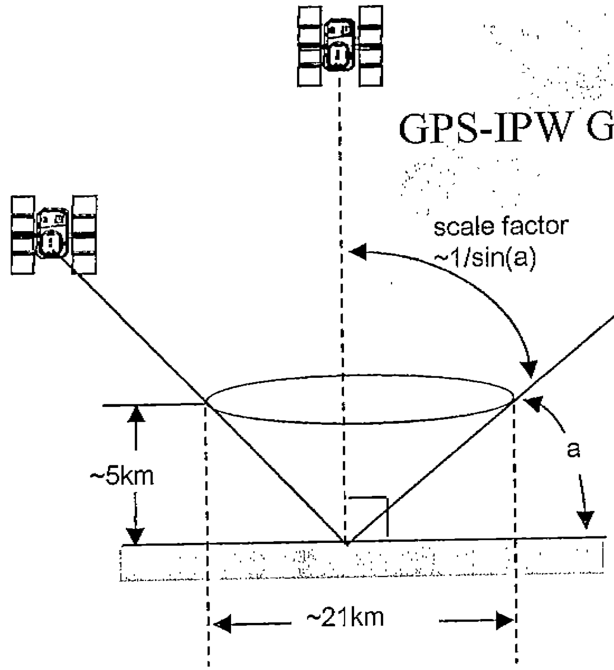
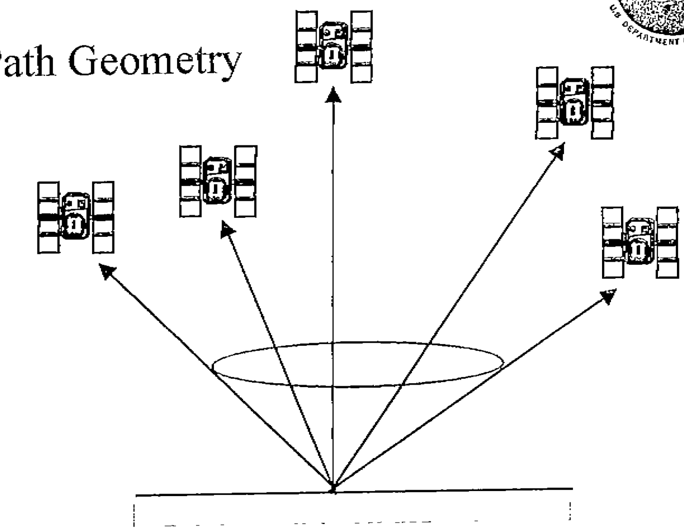
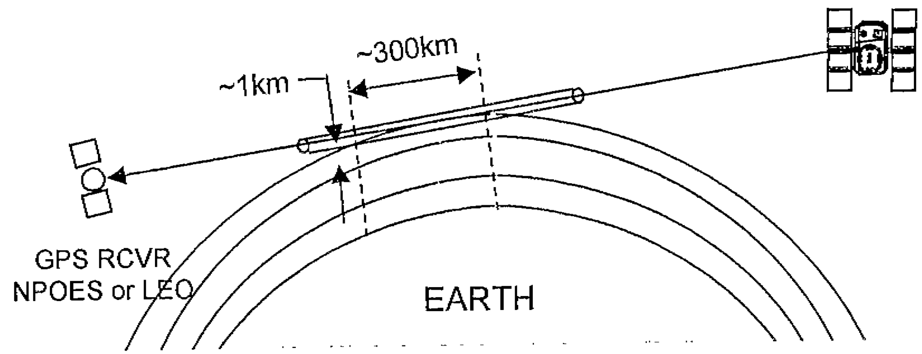
GPS Meteorology Overview



NOTES: Average elevation angle (a) at mid latitudes ~ 25^0

Mapping functions determine how the signal delay changes with elevation angle.





Space Based Geometry

Fundamental Measurement

$$L_s = \int n(s)ds$$

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Ground-Based GPS Meteorology

- GPS-Met is a collection of techniques that measure the signal delays caused by the neutral atmosphere. The most mature is a ground-based technique called GPS-IPW.
- GPS-IPW uses stationary dual frequency GPS receivers, improved orbits, and data processing techniques derived from geodesy to estimate signal "delays" caused by the troposphere, and parse them into their wet and dry components.
- Because of its variability in time and space, tropospheric water vapor introduces delays in the GPS signal that cannot be accounted for analytically.
- For positioning and navigation, these delays are considered *nuisance parameters*, and techniques have been developed to estimate and remove them for high accuracy positioning.

"One Person's Noise is Another Person's Signal"

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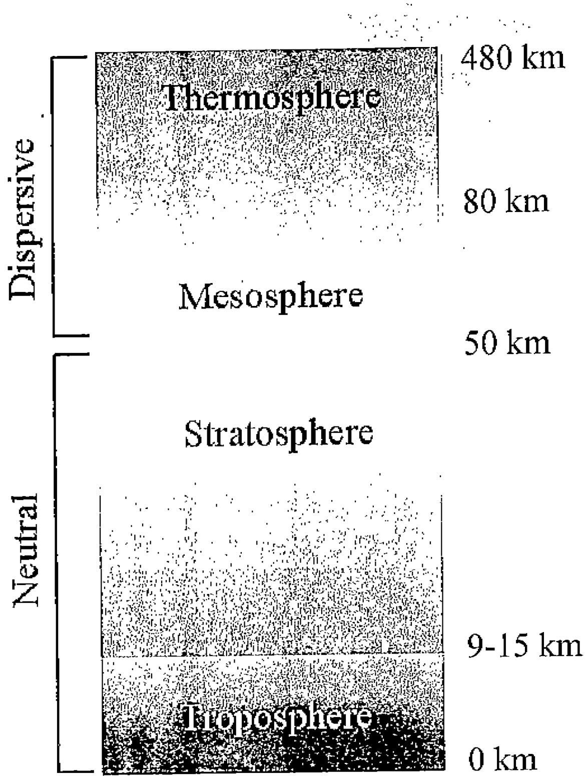
GPS Signal Propagation Through The Atmosphere



- Propagation velocity of EMR in the ionosphere depends on frequency and the refractive index (n) associated with electron density.
- Ionospheric propagation effects can be eliminated using dual frequency receivers since:

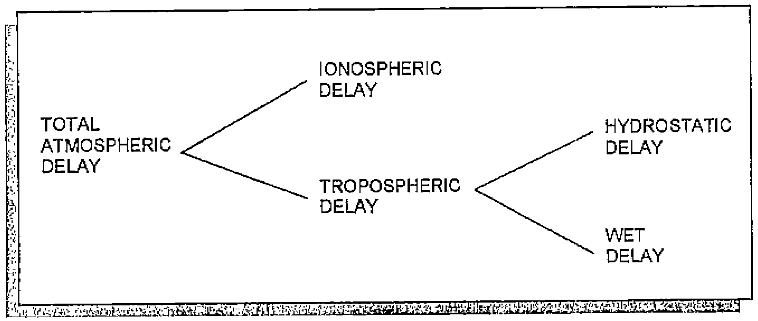
$$\Phi_{IF} \cong 2.546\ \Phi_{L1} - 1.984\ \Phi_{L2}$$

- Below 30 GHz, EMR propagation velocity in the neutral atmosphere depends on the refractive index associated with temperature, pressure and water vapor.

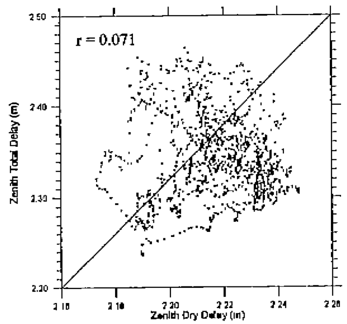
Tropospheric Signal Delay

- After antenna position is estimated, there are always residual errors caused by the slowing and bending of the GPS radio signal in the neutral atmosphere.
- We scale the tropospheric delays to the vertical and average them for 30 minutes to reduce the noise to acceptable limits: < 1 cm RMS.

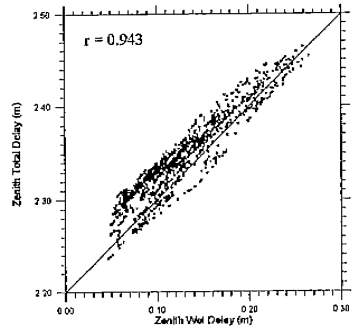
GPS Signal Delay Structure



ZTD vs ZHD



ZTD vs ZWD



- The zenith-scaled tropospheric delay has a wet and dry component that are in the same proportion as the wet and dry components of the atmosphere such that ZTD = ZHD + ZWD

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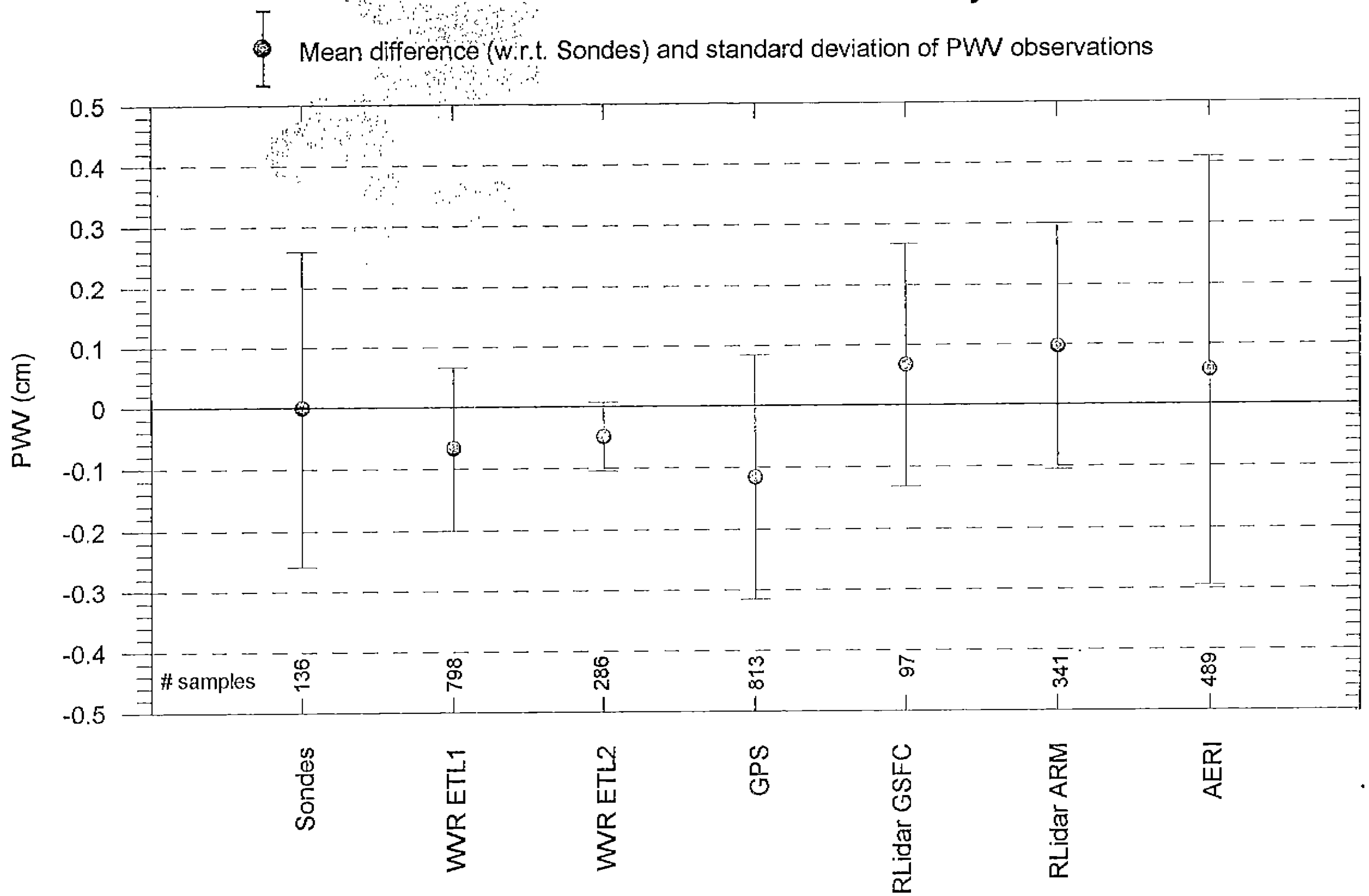
PWV Observing System Accuracy

1997 ARM WVIOP PWV Summary



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GPS-Met In Practice

- We use a network of continuously operating dual frequency GPS receivers and a 'geometrically balanced' array of fiducial sites. At least some of the fiducial sites must be very far (~1000 km) away to separate atmospheric affects from other error sources.
- The same siting criteria used for good GPS positioning apply to GPS-Met. Good sky visibility, low multipath environment, and stable monuments are required.
- Data are acquired in 30-minute sessions to insure that at least one ZTD estimate can be made every hour.
- Orbits with better than 25 cm accuracy must be available on demand to meet the data accuracy and processing requirements. An hourly orbit and 2-hour prediction are currently used for this purpose.

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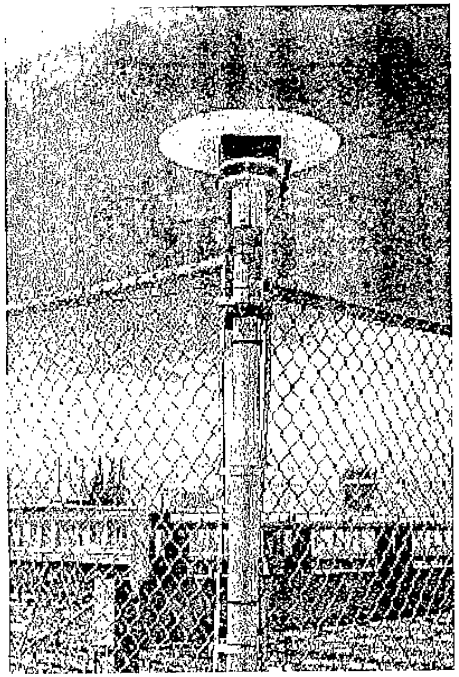
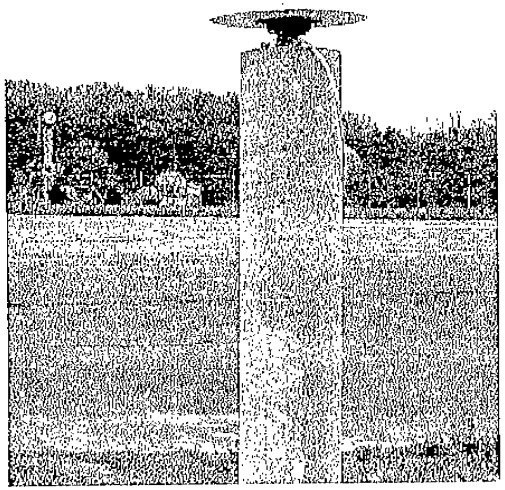
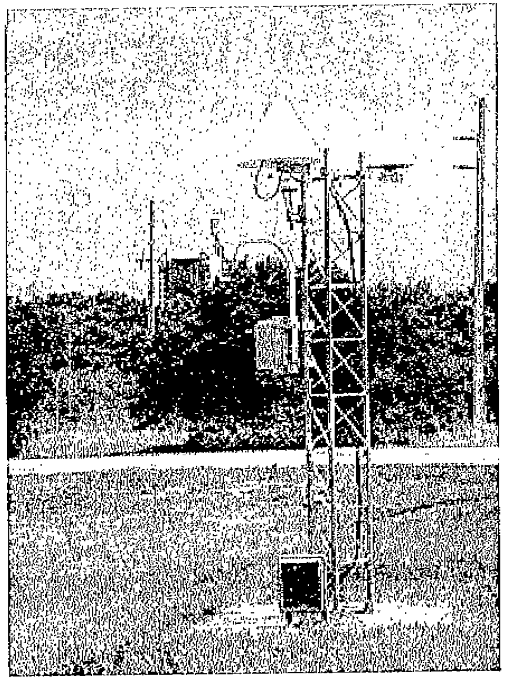
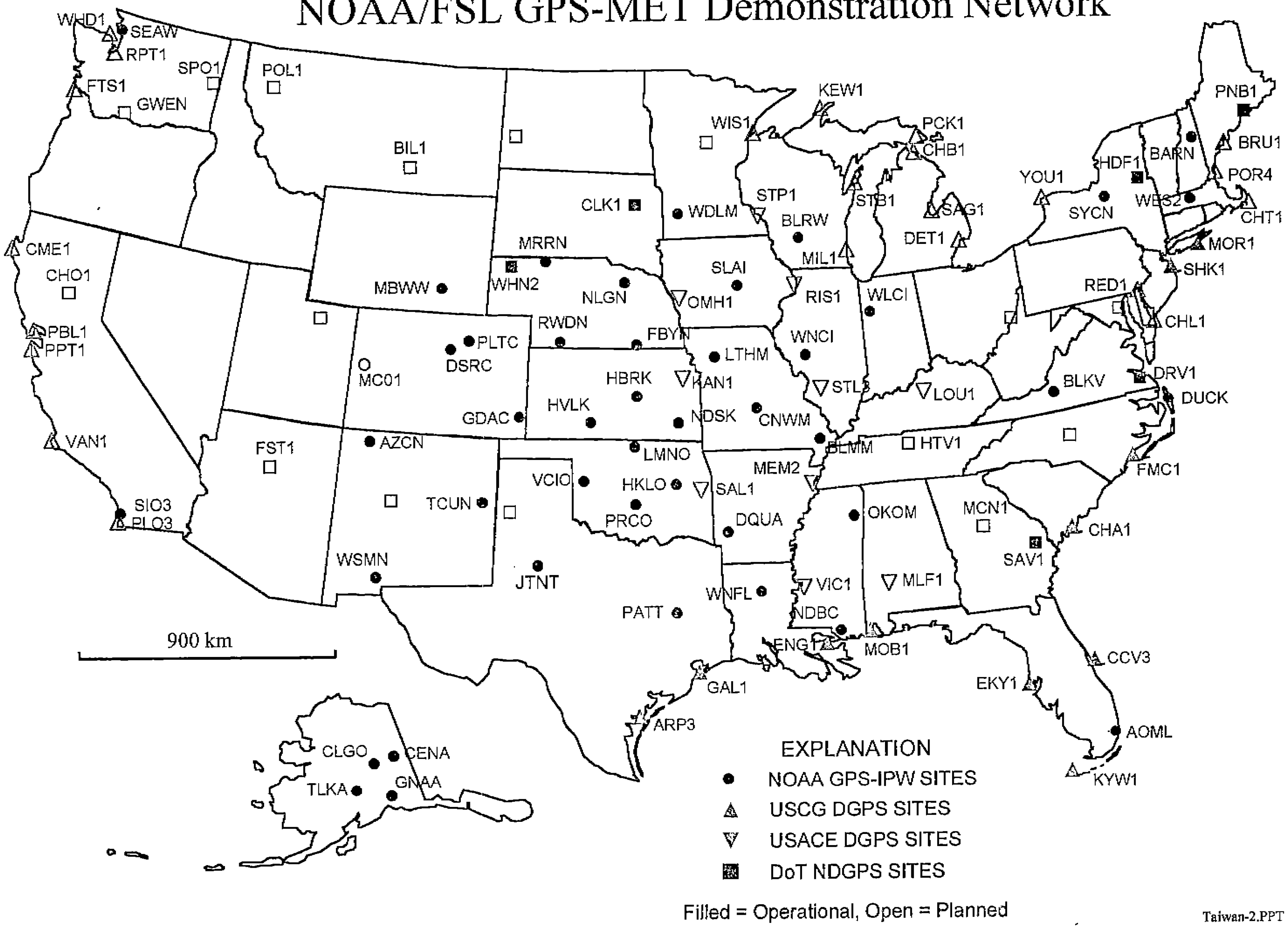
Typical GPS-MET Demonstration Network Sites


NOAA Wind Profiler Sites
Platteville, CO (PLTC)


Other NOAA Sites
Blacksburg, VA WFO (BLKV)


USCG and USDOT DGPS Sites
Cape Canaveral, FL (CCV3)

Current Configuration
NOAA/FSL GPS-MET Demonstration Network



Taiwan-2.PPT

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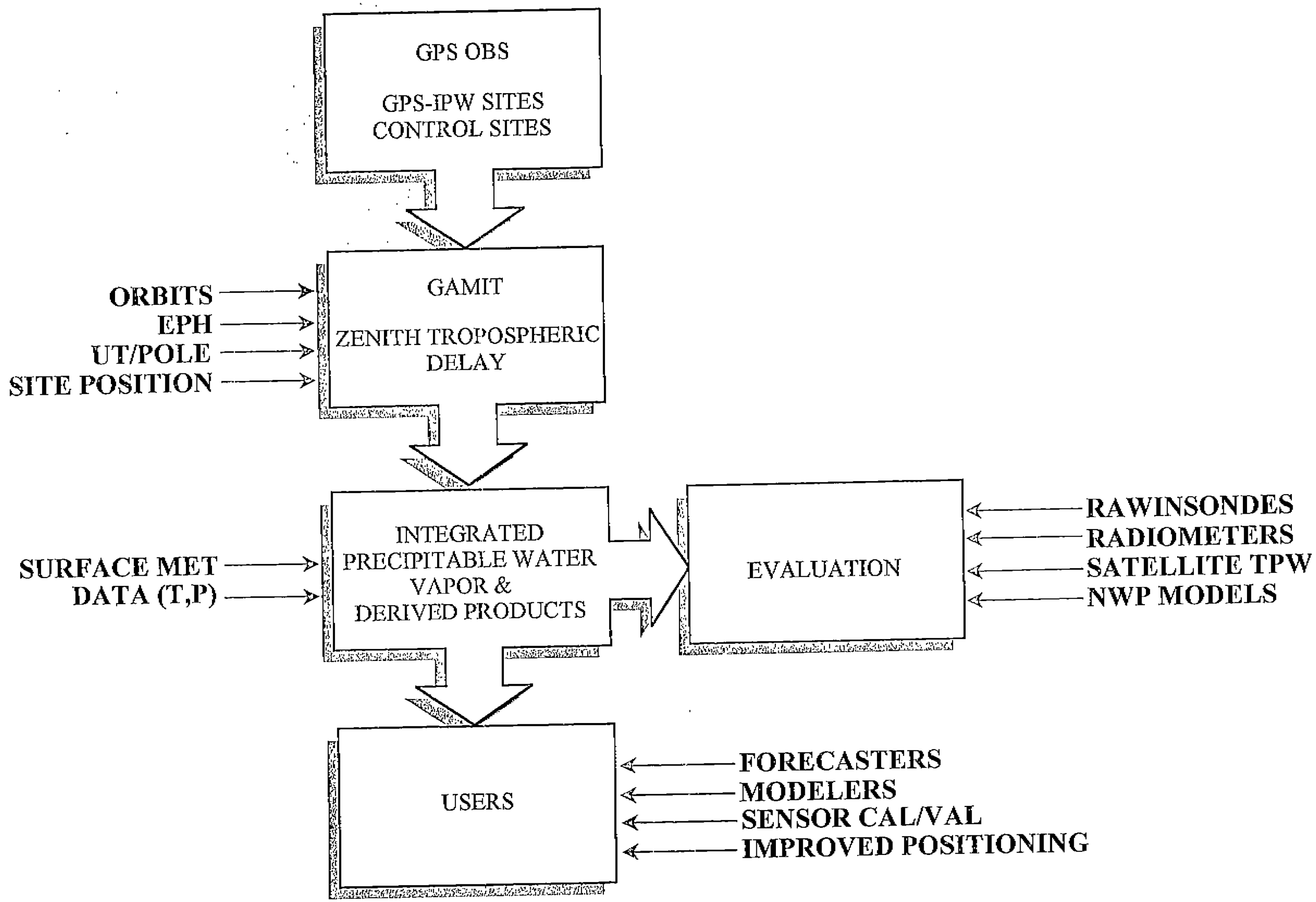
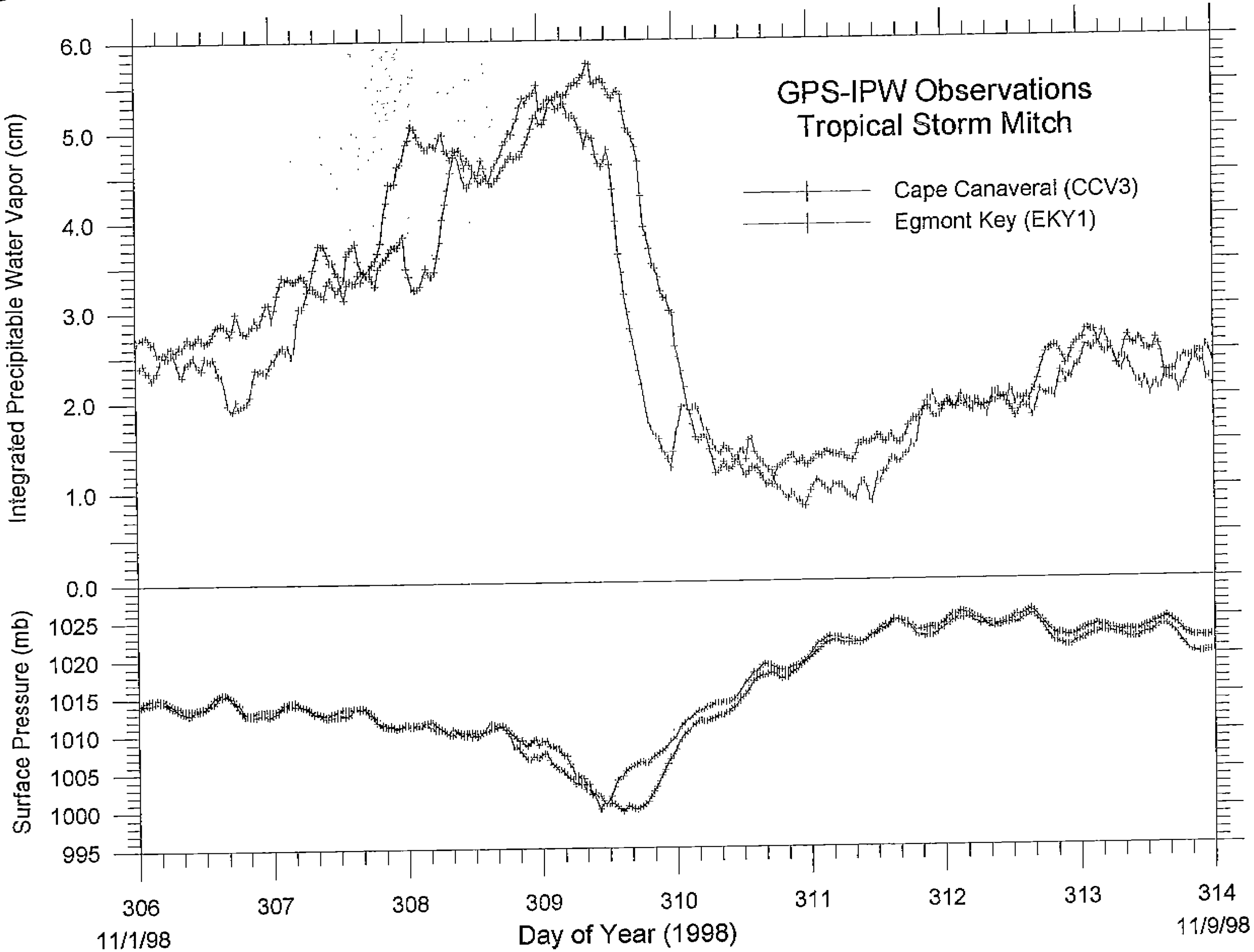
Boulder, Colorado

Generalized NOAA GPS-IPW Data Processing Scheme



FORECAST SYSTEMS LABORATORY
BOULDER, COLORADO

Tropical Storm "Mitch"



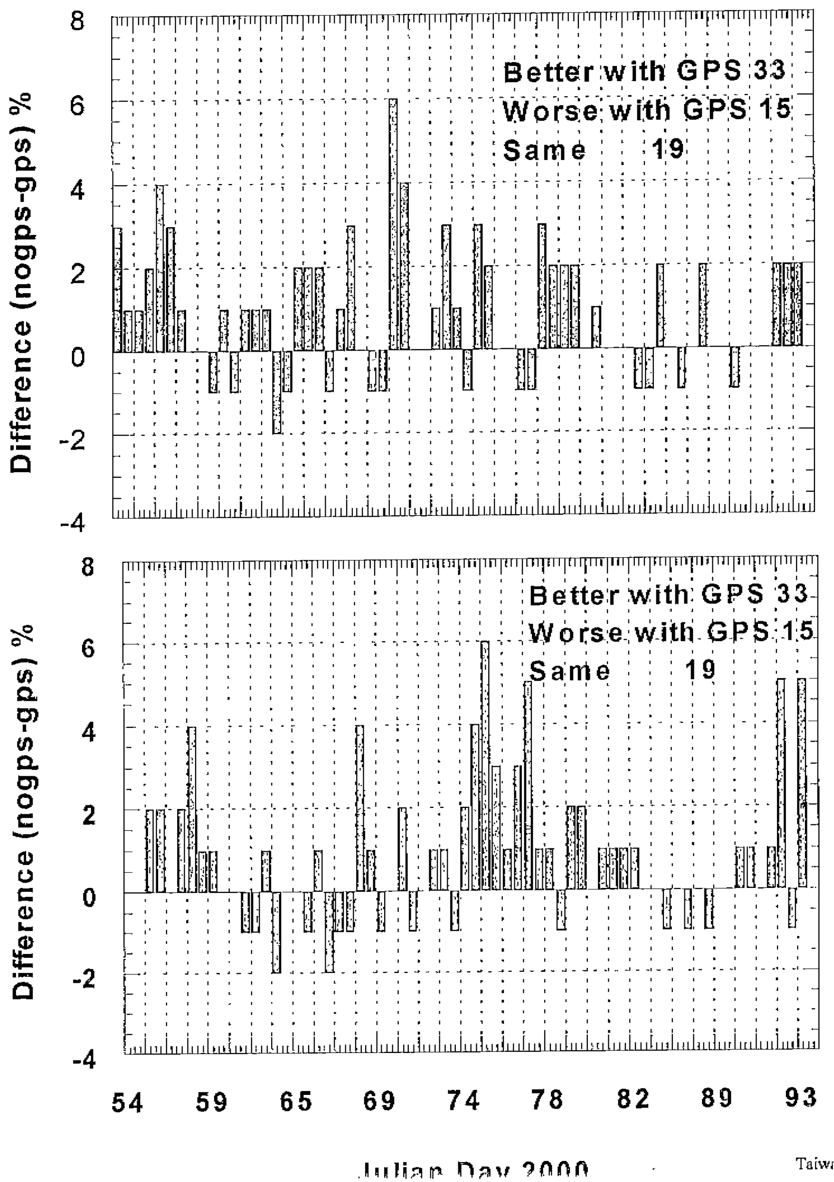
Taiwan-2.PPT

Forecast Systems Laboratory
Boulder, Colorado

Impact of GPS on Wx forecast accuracy

850 hPa Relative Humidity 3-h forecast verification

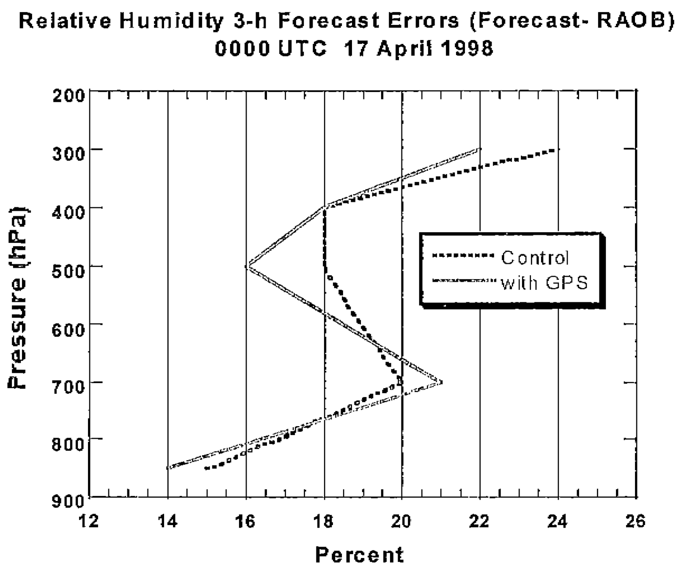
700 hPa Relative Humidity 3-h forecast verification

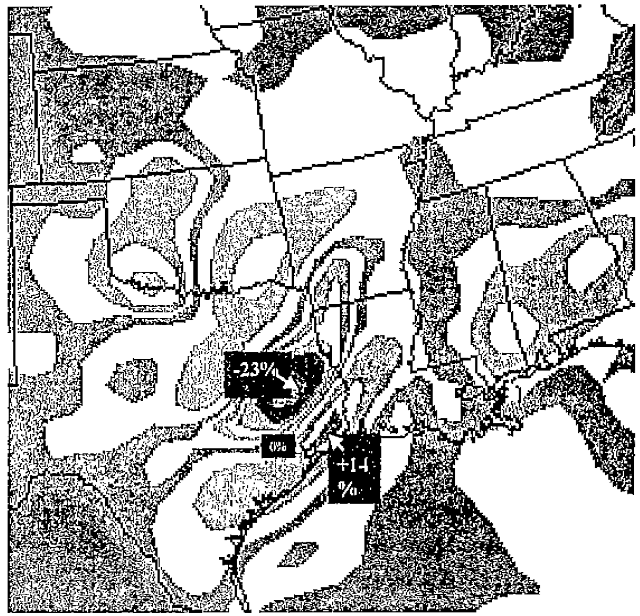


FORECAST SYSTEMS LABORATORY
BOULDER, COLORADO

NWP Case Study: April 16, 1998

- Strong cold front moves through the verification area late in the afternoon. Major severe weather outbreak occurs.
- GPS updates rapidly changing moisture field in-between RAOB times.



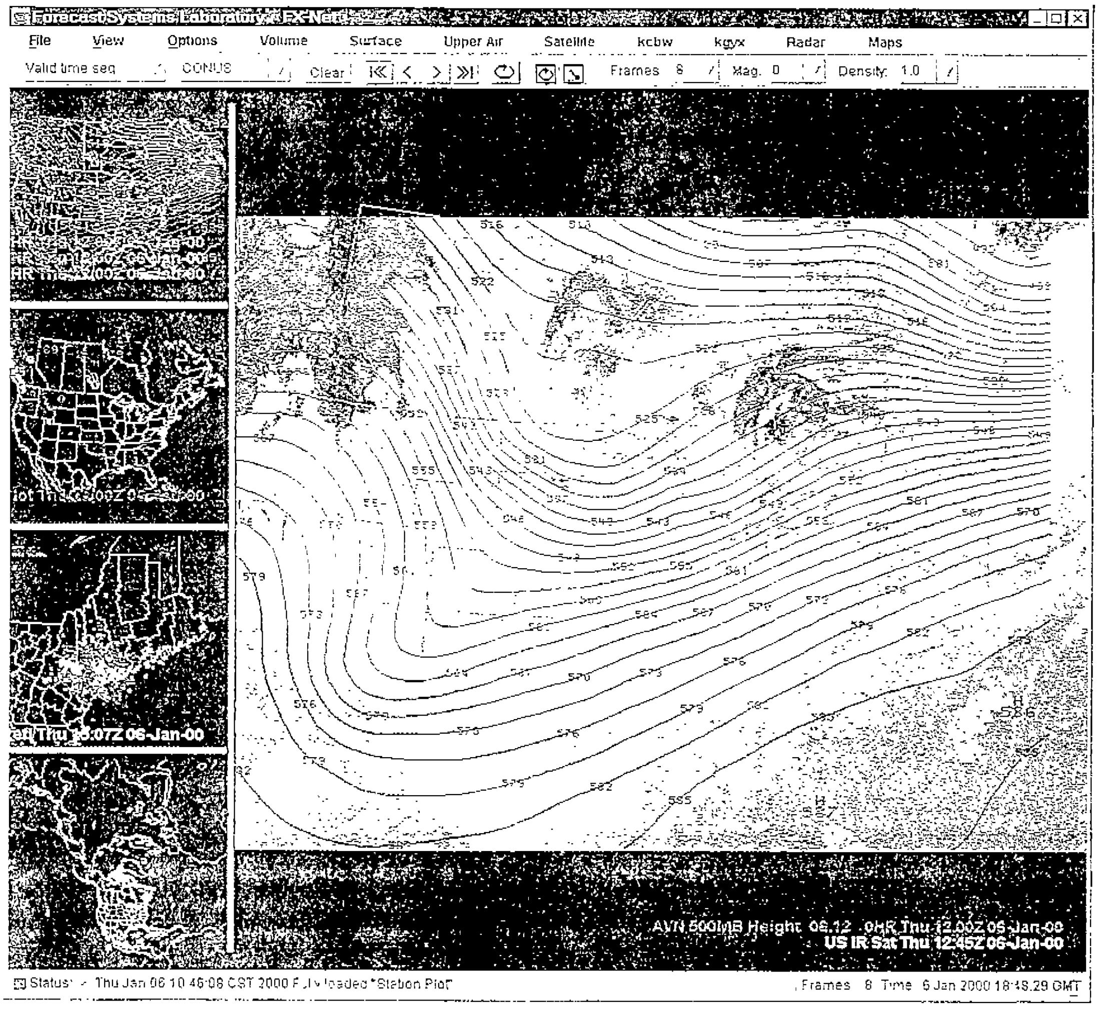


附錄三

FX-Net

Providing Internet Access to AWIPS Products

Sean Madine and Ning Wang
NOAA Forecast Systems Laboratory



*Joint collaboration with the
Cooperative Institute for Research in the Atmosphere,
Colorado State University*

?X-Net to Provide Internet Access to WFO-Advanced Work-station Products

– *By Sean Madine and Ning Wang*

ntroduction

'SL is developing FX-Net, an Internet-based meteoro-ogical PC workstation, that can create sophisticated products using the WFO-Advanced system and transmit hem over the Internet to a client workstation. The client .pplication provides an AWIPS-like user interface with he processing tools needed to interact with products such is satellite, radar, and model imagery.

'X-Net is intended for users who have only modest communications and computing capability. It will serve as in inexpensive, simplified forecast workstation system for ise in a variety of forecast, training/educational, and esearch environments. The less complex system can simulate many WFO-Advanced workstation features, but with some drawbacks, such as reduced resolution.

Two critical challenges that faced the FX-Net developers were to be able to effectively fulfill client requests as quickly as possible, and to accurately represent each meteorological product. Of course the size of the product is an important consideration when preparing it for transmittal over the Internet.

The products associated with this project, particularly weather data, can be categorized into four groups: model imagery, satellite imagery, model graphics, and radar imagery. Of these, satellite imagery is the most difficult to handle because of its large size; for example, an average raw image requires about 700 Kilobytes of space. Model imagery is problematic because of its size as well, and the fact that there are so many products available from so many different models. After investigating all available options, we decided to use a relatively new mathematical tool, the wavelet transform, to compress both model and satellite products. For the purposes of FX-Net, we determined that a small loss of fidelity would be tolerable in exchange for a high compression ratio. Model graphics are represented in a standard vector graphics format, whereas radar imagery is encoded in a standard lossless image compression format. The actual processing time involved in transmitting a given product representation naturally adds to the total time that it takes to fulfill a client request.

Here we discuss the selection and development of a compression technique that best meets the needs of the products transmitted by FX-Net, and the processing strategies implemented for the server and the client in order to optimize delivery time.

Compression Techniques for Product Representation

Model and Satellite Imagery – These images are grouped together because their size demands many common requirements related to compression. The model image contains much less information than a satellite image. In comparison, the compression ratio for the model images is very high (about 80:1). After decompression, both model and satellite images continue to show meteorological detail even with a small loss of fidelity (see figures on page 14). The processing time associated with decompression must not offset the time that is saved during transmission. Further, for processing reasons (discussed more later), the decompression of a particular image frame must be independent of adjacent image frames. The need for high compression ratios along with the tolerance for some loss of fidelity eliminated the use of any of the lossless schemes.

In the context of the above requirements, we investigated the following four compression schemes:

- *JPEG*: Tests of the JPEG [Joint Photographic Experts Group] format achieved good compression, but the fidelity of the decoded image was far from satisfactory. JPEG-compressed images usually exhibit some blocky effects at a compression ratio as low as 10:1.
- *MPEG*: Tests of the MPEG [Moving Pictures Experts Group] format achieved a high compression ratio (about 35:1) by exploiting the time continuity of the series of frames. MPEG hardware is also readily available for use by the client workstations. There are, however, two major problems with the use of this format: because it takes advantage of time continuity, a decoder must wait for all frames to arrive before initiating the decompression processing; and the fidelity quality of the resultant image loop is unsatisfactory. As in JPEG, the blocky effect that is introduced degrades the image far too much for use in a meteorological forecasting system.

• *Fractal Coding Method:* We also tested the fractal (or attractor) coding method, which is a variant of the image vector quantization compression method. Advantages of this approach include a high compression ratio and fast decompression time. However, the quality of the decompressed image is very low in the context of meteorological use. Since this method does not rely on basis functions (e.g., the sine and cosine functions in a Fourier transform) as a means of representation, it is difficult to achieve a desired fidelity even at the cost of a lower compression ratio.

• *Wavelet Transform:* Introduced in the early 1990s, the wavelet transform has remained a cutting edge technology in image compression research. Like the Fourier transform, it relies on a particular set of basis functions, but with a significant difference. The set of basis functions that the wavelet transform uses is localized in both space and frequency, whereas the Fourier transform only contains frequency information.

Because the wavelet transform contains some spatial information in addition to the frequency information, it can achieve excellent compression of meteorological images. Besides this, the wavelet transform also fulfills the other representation requirements. The loss of fidelity is acceptable (see the figures), the decompression processing is reasonable, and the image frames are individually compressed. By exploiting the time continuity of the series of frames, the three-dimensional wavelet compression might yield a higher compression ratio, but it also introduces some interframe dependencies. (This is being investigated.) Batch generation of the compressed products and real-time decompression of images by the client are discussed later.

The three types of satellite imagery that are available through FX-Net are infrared, visible, and water vapor. Each of these has different characteristics in terms of the wavelet transform [illegible] aling with these variables, we took advantage [illegible] he wavelet transform feature that enables us t[illegible] the compression with a judicious choice c[illegible] unctions. For example, an infrared satellit[illegible] e transformed with one choice of wavelet basis has higher fidelity than that of an image transformed with another choice of wavelet basis. The compression scheme that is used follows the standard transform-quantization-entropy coding procedure, which can be used in other types of schemes.

The images on the next page illustrate the lossy nature of the wavelet transform compression scheme. An original satellite image of water vapor is shown in Figure 1a, with Figure 1b showing a magnified view of a cloudy moist area (lower right). Figure 2a shows a 20:1 compressed representation of the full image (1a), with the same magnified view in Figure 2b. Very little information is lost at 20:1, and it is still very useful to the meteorological forecaster or researcher. Figure 3a shows a 50:1 compressed representation of the original full image, with the same magnified view in 3b. The degradation is more objectionable at 50:1, and the image may no longer be useful.

Model Graphics – Model graphics are represented in a vector graphics format called Dare Graphics Metafile (DGM). An important aspect of this format is that it offers a compact representation of the model graphics; e.g., a typical CONUS 500-mb Height Contour DGM file is on the order of 15 kilobytes in size. The FX-Net system also uses the DGM to encode progressive disclosure information about the graphics, which enhances the client's ability to perform efficient zoom display operations.

Radar Imagery – Radar imagery must be represented differently than the satellite and model imagery because there is no tolerance for loss in the radar signal. For instance, the use of wavelet compression could introduce an artificial feature or even mask a dangerous storm feature that does in fact exist. Since radar imagery also contains much less information (in terms of signal) than satellite imagery, and there is no tolerance for loss, FX-Net compresses radar imagery in a lossless manner. This was accomplished using a standard format, Graphical Interchange Format (GIF); tests verified that it works well for radar images. The compression ratio varies significantly depending on the amount of information in the radar image. The size of even the largest resultant radar files is manageable using the FX-Net scheme.

FX-Net to Provide Internet Access to WFO-Advanced Products *(continued)*

Figure 1a. An original, raw satellite image showing water vapor.

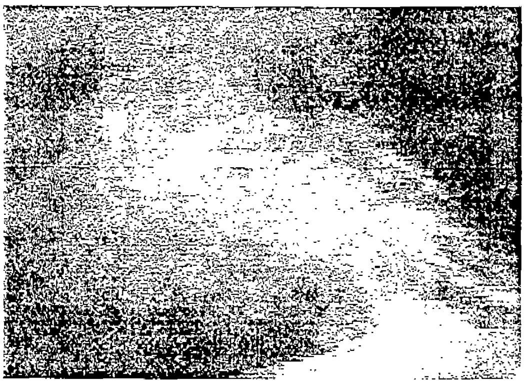


Figure 1b. A magnified view of a moist cloudy area (1a, lower center) showing a good deal of fine-scale structure.

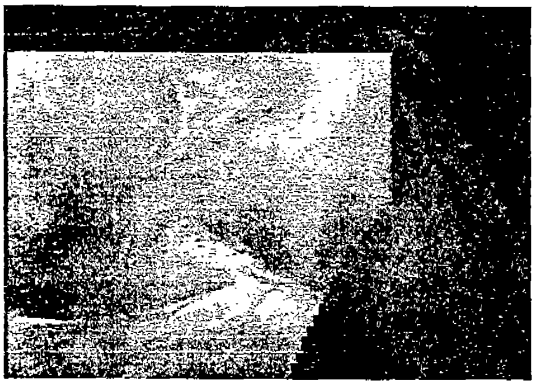


Figure 2a. A 20:1 compressed representation of the original image (Figure 1a).

Figure 2b. A magnified view of Figure 2a showing a slight but acceptable degradation.

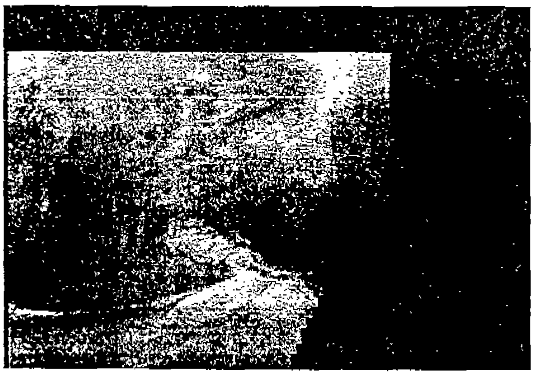


Figure 3a. A 50:1 compressed representation of the original image (Figure 1a).

Figure 3b. A magnified view of Figure 3a showing that the image has now become more objectionable.

Processing Strategies

Server – It is important to address the processing associated with the various formats that have been chosen for the FX-Net products. The vector graphics format is inexpensive for both encoding on the server and decoding (displaying) on the client computer/workstation. Similarly, GIF encoding and decoding do not contribute significantly to the total time associated with product delivery. The wavelet transform, however, is compute-intensive, particularly on the server side.

Besides the actual wavelet transform, the compression routine on the server involves a dynamic search for the optimal set of basis function coefficients that are used to represent the image. This dynamic search greatly enhances the ability to compress the image at the cost of increased processing time, especially for satellite imagery where the compression ratio is critical. The cost in time can be on the order of 20 seconds per image frame. For the set of available satellite imagery, frames are compressed immediately upon arrival from the data ingest system. Thus, any requests for satellite imagery by a client can be fulfilled without performing the compression processing.

The production of model imagery is quite different. Because there is a huge matrix of possible products, model image products cannot be generated before an actual request. However, the high compressibility of the model images allows the compression routine to bypass the dynamic search for coefficients. Then a best guess set of coefficients is used, and the processing time is reasonable for the necessary on-demand compression.

Client – The decompression of the wavelet-compressed files on the client is also computationally expensive. The processing takes about two to three seconds per image frame when run on a 400-MHz PC. The client takes advantage of the multithreading feature offered by the Java programming language.

By executing decompression and communication threads concurrently, the capabilities of the client hardware are optimally utilized. Each individual image frame is displayed for the user as the decompression completes, thus minimizing the perceived wait for the product arrival.

Concluding Remarks and Future Work

Now that Internet communications have become faster, and available client hardware provides better processing capability, the concept of a network meteorological workstation is more viable. Many factors go into the design of such a workstation. Effective delivery of the products from the server to the client is an integral consideration in the FX-Net project. This includes not only accurate representation of the various products, but efficient processing associated with those representations.

The next major goal for the FX-Net project is the installation of an operational real-time system that will support an undergraduate meteorology curriculum at Plymouth State College in New Hampshire. As development continues, future enhancements could include access to case study data and support of multiple local radar datasets.

With the advent of wireless Internet connectivity and powerful laptop computers, FX-Net can be accessed even in remote areas. One example is that forecasters could be called upon to provide an on-site weather analysis in an area where a blazing fire is out of control. FX-Net would enable the forecasters near the site to access AWIPS products available hundreds of miles away at a National Weather Service forecast office.

Note: Special thanks to Steve Albers, a researcher in the Forecast Research Division, for offering his expertise regarding the satellite images.

(Sean Madine and Ning Wang are computer programmers in the International Division, headed by Dr. Wayne Fischer. They can be reached at http://www-id.fsl.noaa.gov.)