行政院及所屬各機關出國報告
（ 出國類別：實習 ）

中美氣象預報發展技術合作—即時校驗系統

服務機關： 交通部中央氣象局
出 國 人　職　　稱： 薦任技佐
姓　　名： 曾俊二

出國地區： 美國
出國期間： 民國 93 年 5 月 3 日至民國 93 年 10 月 29 日
報告日期： 民國 93 年 11 月 15 日

行政院及所屬各機關出國報告提要

系統識別號：C09304558

出國報告名稱：中美氣象預報發展技術合作—即時校驗系統（Real Time Verification System－RTVS）

頁數 47　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

曾俊二/交通部中央氣象局/氣象衛星中心/薦任技佐/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 5 月 3 日 至民國 93 年 10 月 29 日　　出國地區：美國

報告日期：民國 93 年 11 月 15 日

分類號/目：H8/氣象 H8/氣象

關鍵詞：即時校驗系統（RTVS，Real-Time Verification System）

內容摘要：（二百至三百字）

即時校驗系統（RTVS）提供統計資訊作為中央氣象局與美國海洋暨大氣總署所屬的預報系統實驗室（FSL, Forecast Systems Laboratory）技術合作，發展台灣地區中尺度模式短時預報系統—Taiwan Hot-Start MM5 模式數值預報技術改善之參考。

此系統以近乎即時方式擷取模式預報與實際觀測資料儲存於系統之資料庫。提供網頁之圖形使用者介面讓使用者能快速、容易地操作，使用者可在選取的時間區段上比較不同預報長度與預報發佈時間的實際觀測與模式預報資料的統計分析，且快速顯示圖形化產品讓使用者參考。即時校驗系統可作為天氣預報品質評估之工具。

職此行的主要任務為即時校驗系統（RTVS）之系統資料庫建立與原始程式碼研讀實習及增修功能的程式碼撰寫。

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

行政院及所屬各機關出國報告
（ 出國類別：實習 ）

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中美氣象預報發展技術合作—即時校驗系統

摘要

即時校驗系統（RTVS）提供統計資訊作為中央氣象局與美國海洋暨大氣總署所屬的預報系統實驗室（FSL, Forecast Systems Laboratory）技術合作，發展台灣地區中尺度模式短時預報系統—Taiwan Hot-Start MM5 模式數值預報技術改善之參考。

此系統以近乎即時方式擷取模式預報與實際觀測資料儲存於系統之資料庫。提供網頁之圖形使用者介面讓使用者能快速、容易地操作，使用者可在選取的時間區段上比較不同預報長度與預報發佈時間的實際觀測與模式預報資料的統計分析，且快速顯示圖形化產品讓使用者參考。即時校驗系統可作為天氣預報品質評估之工具。

職此行的主要任務為即時校驗系統（RTVS）之系統資料庫建立與原始程式碼研讀實習及增修功能的程式碼撰寫。

關鍵詞：即時校驗系統（RTVS，Real-Time Verification System）

目次

一、 目的

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為甚。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，為本局致力於氣象防災、減災的目標。

常見的劇烈天氣為豪雨、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。

此行赴美的主要目的即在研習美國國家海洋暨大氣總署所屬的預報系統實驗室（FSL，Forecast Systems Laboratory）所發展的即時校驗系統（RTVS，Real-Time Verification System），本局與美方合作發展台灣地區中尺度模式短時預報系統—Taiwan Hot-Start MM5，此系統即時進行非絕熱初始化及中尺度數值預報，有效改善傳統數值模式存在之模式調整問題，增進極短時預報的成效。而即時校驗系統提供統計資訊來作為模式數值預報改善之參考，以利達成發展台灣地區高效能的天氣預報技術，提升劇烈災變天氣的極短時預報能力之終極目標。

二、 過程

職此次赴美行程及工作概述說明如下表：

日期	地點與相關工作內容
93/5/3	台北→洛杉磯
93/5/4	洛杉磯→丹佛
93/5/5	波德（Boulder）（美國日期為93/5/4）赴美國國家海洋暨大氣總署預報系統實驗室（FSL），與孟繁村博士就此次訪美的工作內容交換意見，並拜會即時預報系統相關成員。
93/5/6~93/6/20	進行區域分析預報系統（LAPS, Local Analysis and Prediction System）系統架構與安裝之研習，並協助NFS模式部分副程式平行化處理。
93/6/21~93/7/3	參加美國大學大氣研究聯盟 (UCAR)舉辦之研討會 "Summer Colloquium on Atmospheric Remote Sensing Using the Global Positioning System"
93/7/6~93/8/31	進行即時校驗系統（RTVS，Real-Time Verification System）系統操作之瞭解，並拜會開發此系統之航空部門預報校驗組主管Jennifer Mahoney 討論RTVS系統技術移轉事宜。
93/9/1~93/9/30	取得校驗系統資料庫建立與地面觀測場校驗程式原始程式碼，開始進行程式碼研讀，並與原始撰寫人進行程式之技術細節討論。
93/10/1~93/10/27	取得校驗系統地面觀測場校驗程式使用者圖形介面版本原始程式碼，開始進行程式碼研讀，並與原始撰寫人進行程式之技術細節討論。
93/10/28	丹佛→洛杉磯
93/10/28~10/29	洛杉磯→台北

工作內容說明如下：

五月份：在生活上安置妥當之後，旋即開始在此間的工作。開始著手區域分析預報系統（LAPS）有關系統架構與安裝細節的了解。

六月份：協助 NFS 模式部分副程式平行化處理的修改與測試；6 月 21 日至七月三日參加美國大學大氣研究聯盟（UCAR, The University Corporation for Atmospheric Research)舉辦之研討會 "Summer Colloquium on Atmospheric Remote Sensing Using the Global Positioning System"。於此研討會上得一窺中華

衛星三號計畫 GPS 技術上的發展現況及方向，更有助於職對 GPS 可降水量相關技術之應用暨解決方案有更進一步的瞭解。。

七月份到八月份：進行即時校驗系統（RTVS，Real-Time Verification System）系統網頁操作之瞭解與閱讀相關參考文獻進一步了解有關系統架構；並拜會開發此系統之航空部門預報校驗組主管 Jennifer Mahoney 討論 RTVS 系統技術移轉事宜。

九月份：取得校驗系統資料庫建立與地面觀測場校驗程式原始程式碼，開始進行程式碼研讀，並與原始撰寫人進行程式之技術細節討論。經由網際網路將原始程式碼傳回本局安裝，及協助本局的工作小組解決所遭遇到的問題。

十月份：取得校驗系統地面觀測場校驗程式使用者圖形介面版本原始程式碼，開始進行程式碼研讀，並與原始撰寫人進行程式之技術細節討論。經由網際網路將原始程式碼傳回本局安裝，及協助本局的工作小組解決所遭遇到的問題。

三、 心得

即時校驗系統（RTVS）提供預報員和模式開發者之參考，此系統以近乎即時方式擷取模式預報與實際觀測資料儲存於系統之資料庫。提供網頁之圖形使用者介面讓使用者能快速、容易地操作，使用者可在選取的時間區段上比較不同預報長度與預報發佈時間的實際觀測與模式預報資料的統計分析，且快速顯示圖形化產品讓使用者參考。即時校驗系統可作為天氣預報品質評估之工具。

即時校驗系統（**RTVS, Real-Time Verification System**）：

美方目前線上作業的即時校驗系統（RTVS）分為對流（Convection)、湍流（Turbulence） 、積冰（Icing） 與 雲幂和能見度（Ceiling and Visibility） 等四大部分（圖一)。

1. 對流（Convection）

預報對流型態的校驗（圖二)，可校驗的預報產品有重大對流氣象報告（C-SIGMETs ,Convective Significant Meteorological Advisory)、重大對流氣象報告展望（C-SIGMETs Outlook）、共同合作對流預報產品（CCFP ,Collaborative Convective Forecast Product)與國家對流天氣預報(NCWF ,National Convective Weather Forecast)等四種。有關對流校驗系統使用者說明手冊（如附件一)。

2. 湍流（Turbulence）

預報湍流型態的校驗（圖三)，可校驗的預報產品有航空交通人員氣象報告(AIRMETs ,Airmen's Meteorological Advisories)、 無訂正之航空交通人員氣象報告（AIRMETs without amendments）、重大氣象報告（Significant Meteorological Advisories (SIGMETs)，無取消之重大氣象報告（SIGMETs without cancellations）與圖形化湍流指南(GTG,Graphical Turbulence Guide) 等五種。有關湍流校驗系統使用者說明手冊（如附件二)。

3. 積冰（Icing）

預報積冰型態的校驗（圖四)，可校驗的預報產品有航空交通人員氣象報告(AIRMETs ,Airmen's Meteorological Advisories)、 無訂正之

航空交通人員氣象報告（AIRMETs without amendments）、重大氣象報告（Significant Meteorological Advisories（SIGMETs)、 無取消之重大氣象報告（SIGMETs without cancellations）、現行積冰潛勢(CIP ,Current Icing Potential)與預報積冰潛勢(FIP ,Forecast Icing Potential）等六種。有關積冰校驗系統使用者說明手冊（如附件三）

4. 雲冪和能見度（Ceiling and Visibility）

預報雲冪和能見度型態的校驗（圖五），可校驗的預報產品有航空交通人員氣象報告(AIRMETs ,Airmen's Meteorological Advisories)、 無訂正之航空交通人員氣象報告（AIRMETs without amendments）、國家尺度雲冪報告（NCV Ceiling)、國家尺度雲冪和能見度報告（NCV Ceiling and Visibility）與國家尺度能見度報告（NCV Visibility）等五種。有關雲冪和能見度校驗系統使用者說明手冊目前尚未公布。

即時校驗系統提供統計資訊可作為中央氣象局與美國海洋暨大氣總署所屬的預報系統實驗室（FSL, Forecast Systems Laboratory）技術合作，發展台灣地區中尺度模式短時預報系統—Taiwan Hot-Start MM5 模式數值預報技術改善之參考。針對此預報系統所提供之即時校驗系統版本，目前完成的是地面狀態變數的觀測點校驗。

一、 系統軟體需求

1. 作業系統：Linux
2. MySQL 資料庫
3. Perl
4. NETCDF
5. NETCDFPerl
6. gnuplot

二、　校驗系統程式可分成兩大部分 1. 資料庫部分。2. 統計計算校驗與繪圖部份。

1.資料庫部分 MySQL

主要目的是將實際觀測資料與模式預報資料寫入資料庫，作為未來統計計算校驗之用。實際觀測資料包含地面觀測的溫度、露點、風向、風速、海平面氣壓與雨量。模式預報資料則有 MM5 模式與 WRF 模式。將欲校驗時間的實際觀測資料與相對時間的模式預報資料寫入同一個檔案，主檔案名稱命名以地面觀測狀態變數--溫度(temp)、露點(dewp)、風向(wdir)、風速(wspd)、海平面氣壓(mslp)與雨量(rn1)做主要區分，例如 temp_rt06_fh08 ： temp 代表溫度場資料，rt06 代表實際觀測時間 06Z 資料，fh08 代表 06Z 模式預報 8 小時的預報場資料。程式以 CRON 控制固定時間起來將資料寫入資料庫。

2.統計計算校驗與繪圖部份

主要目的是將實際觀測資料與模式預報資料從資料庫讀出，經過統計計算並繪成圖檔。統計校驗計算方法: a. RMS　b. Bias。利用 gnuplot 繪製成 png 格式的圖檔。程式提供網頁之圖形使用者介面（圖六）讓使用者選擇開始時間、結束時間、欲校驗之狀態變數、初始時間、觀測站、預報長度與預報模式（MM5 或 WRF），選擇完畢後按 submit 開始執行，系統經過計算繪圖後隨之將 png 格式的圖檔顯示在網頁上，目前顯示的圖檔: 1. v-biX.png ---> Bias 2. v-maX.png ---> Mean Absolute Error 3. v-rmX.png ---> Root Mean Squared 。

四、 建議

劇烈降水所引發的淹水、山崩與土石流等，是造成近年來台灣地區人民生命、財產重大損失的天然災害。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，以落實氣象防災、減災的目標。本局與美方 NOAA/FSL 合作發展台灣地區中尺度模式短時預報系統之預報結果，並須透過真實、確實的校驗，才能掌握模式預報特性與誤差，且加以改進。職此次赴美學習之即時校驗系統，可作為預報系統改進之依據。

今年完成的即時校驗系統版本，係針對地面狀態變數以觀測站為基準的點校驗。未來朝向以下方向努力，透過校驗持續提升預報準確度。

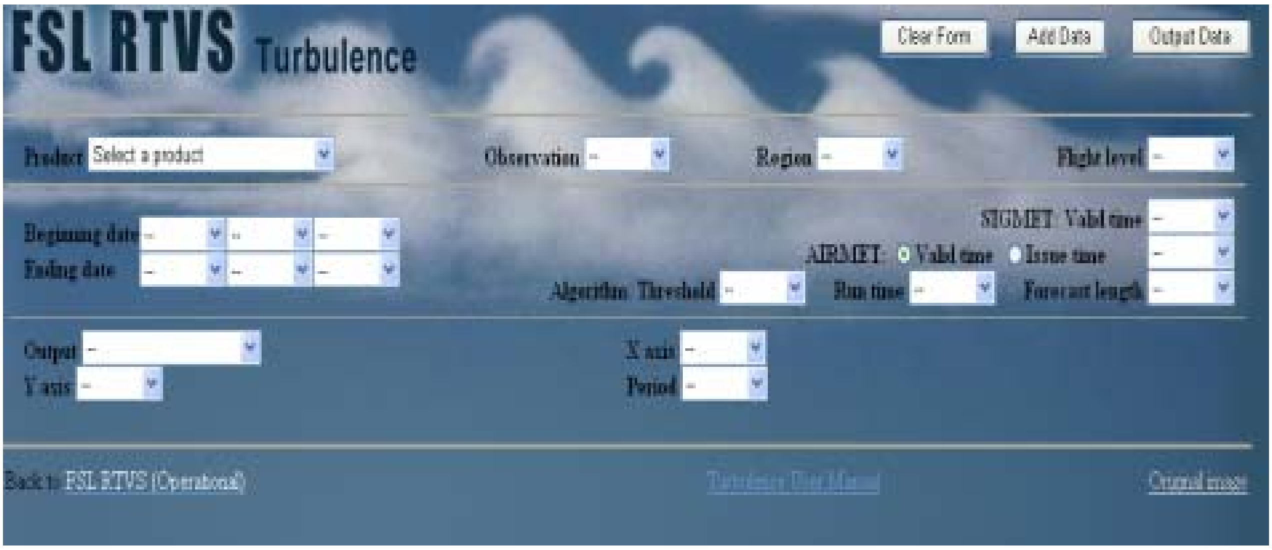
1. 柱狀校驗(Column verification)

2. 降水校驗

   - 定量降水預報（QPF）
   - 雷達降水回波（Reflectivity）
   - 降水機率預報 POP（Brier Scores）

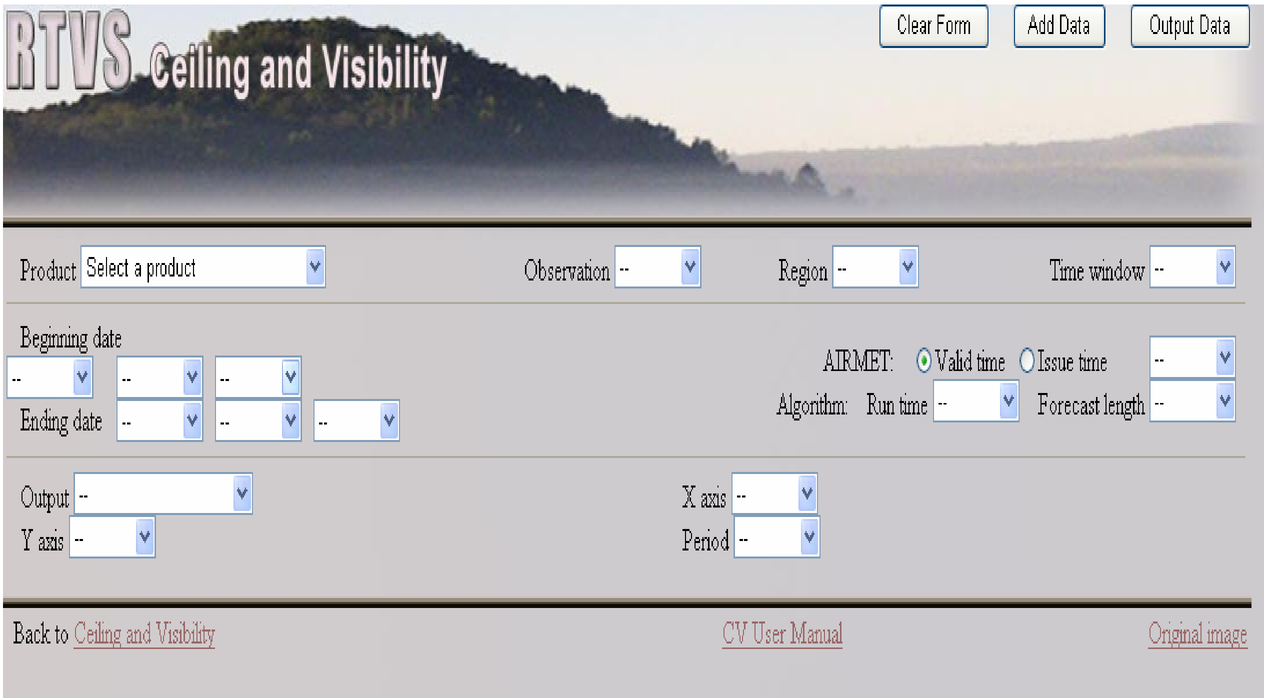
圖一：美方目前線上作業的即時校驗系統（RTVS）。

圖二：對流的校驗之圖形使用者介面。

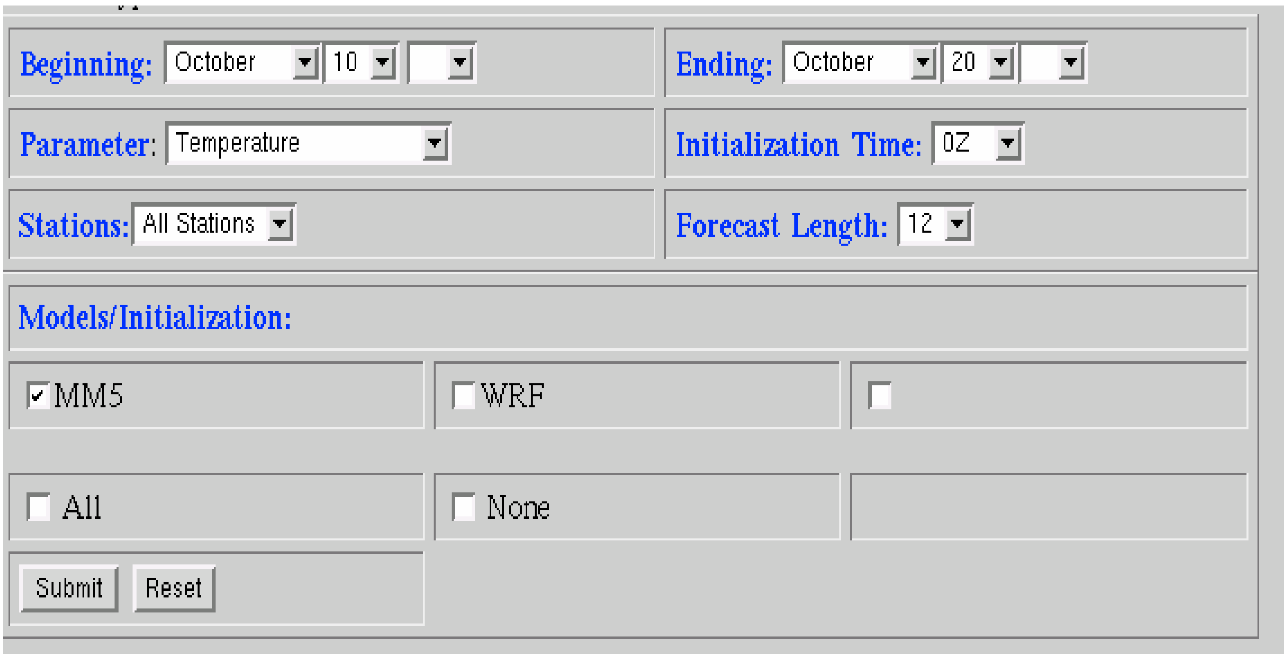


圖三：湍流的校驗之圖形使用者介面。

圖四：積冰的校驗之圖形使用者介面。



圖五：雲冪和能見度的校驗之圖形使用者介面。



圖六：目前即時校驗系統版本之圖形使用者介面。

附件一

Operational Convection On-line User Manual

Version 20041014

Table of Contents

1.0 Product

The product refers to the type of forecast being verified. There are four possible selections available to the user for operational convection, including the Convective Significant Meteorological Advisory (C-SIGMETs), C-SIGMETs Outlook, Collaborative Convective Forecast Product (CCFP), and National Convective Weather Forecast (NCWF).

1.1 C-SIGMETs (Convective Significant Meteorological Advisory)

The C-SIGMET, generated by forecasters at the Aviation Weather Center (AWC), is a text forecast of convective activity that is issued hourly, but is valid for up to 2 hours (National Weather Service 1991). The forecasts are intended to capture severe or embedded thunderstorms and their hazards (e.g., hail, high winds) that are either occurring or forecasted to occur within 30 minutes of the valid period and cover at least 40% of the 2,000 square mile or larger forecast area. C-SIGMETs include a description of phenomena compiled from radar reports, satellite data and Pilot Reports (PIREPs). C-SIGMETs are issued at 55 minutes after the hour.

Any C-SIGMET implies severe or greater turbulence, severe icing, and low-level wind shear. A C-SIGMET may be issued for any convective situation that the forecaster feels is hazardous to all categories of aircraft.

1.2 C-SIGMETs Outlook

The convective outlook is an operational text forecast of convective activity, generated by AWC meteorologists, issued hourly, and valid from 2-6 hours after the issuance time of the C-SIGMET outlook (National Weather Service 1991). The text is decoded into latitude and longitude vertices. The forecast area encompasses moving and changing weather over the 4-hour period. C-SIGMETs are issued at 55 minutes after the hour.

1.3 CCFP (Collaborative Convective Forecast Product)

The CCFP is prepared through a multiple-set collaborative process (Weather Applications Workgroup 2003; Hudson and Foss 2002; Phaneuf and Nestoros 1999) that begins with AWC forecasters, but includes participation from airline meteorologists and dispatchers, as well as meteorologists from the Center Weather Service Units (CWSUs) at the Air Route Traffic Control Centers (ARTCCs). The CCFP is used as a strategic decision aid by the decision-makers at the airlines and the Air Traffic Control System Command Center (ATCSCC) for rerouting air traffic around convective weather. The times listed in the table occurred after the change to daylight savings. Prior to daylight savings, the CCFP is issued 1 hour earlier.

1.4 NCWF (National Convective Weather Forecast)

The National Convective Weather Forecast (NCWF) product, designed and implemented by the National Center for Atmospheric Research (NCAR), provides 1-hour extrapolation forecast polygons of thunderstorm hazard locations. The forecasts update every 5 minutes.

The NCWF target users are airline dispatch, general aviation and FAA Traffic Management Units (TMU). The NCWF product is available on the WWW via the Aviation Digital Data Service (ADDS) and on FAA-CDMnet.

For more information on how NCWF forecast polygons are determined, refer to this website.

2.0 Observation

2.1 C-SIGMETs (Convective Significant Meteorological Advisory)

C-SIGMETs are used as an observation in the verification of the CCFP. Considering the valide time of a CCFP forecast, the C-SIGMET issued closest to this valid time is utilized as truth.

2.2 NCWF Detection Field

The NCWF Detection Field is a convective hazard field depicting areas of convective weather that may be hazardous to aviation. The hazard field is based on WSR-88D National Radar Mosaics and National Lightning Detection Network cloud-to-ground lightning data (Orville 1991). The echo tops data are used to threshold the radar-derived Vertically Integrated Liquid (VIL) observations. The VIL data are provided in the WSR-88D Information Dissemination Services (NIDS) WSR-88D product stream and are mapped to a national mosaic by UNISYS. The VIL field is calculated by using an empirical formula to derive liquid water content from radar reflectivity at each elevation. The data are then integrated with height to obtain VIL. The VIL observations provide information about the intensity of a storm throughout its vertical extent, and are a proxy for vertical development. VIL values are translated to a Video Integrator and Processor (VIP) scale.

3.0 Stratification

3.1 Region

Statistics are generated for four specific regions. Each of the regions has been defined to follow AWC requirements.

3.1.1 National

The boundary surrounding the U.S., shown in Figure 3.1, is an example of the National region used to evaluate the convective forecast products.

3.1.2 East

The East region is located eastward from a north/south line extending from the Great Lakes through the Tennessee Valley to the Gulf Coast, as shown in Figure 3.1.

3.1.3 Central

The Central region extends west from the Eastern region to a north/south line located east of the Dakotas, Colorado, and New Mexico, as shown in Figure 3.1.

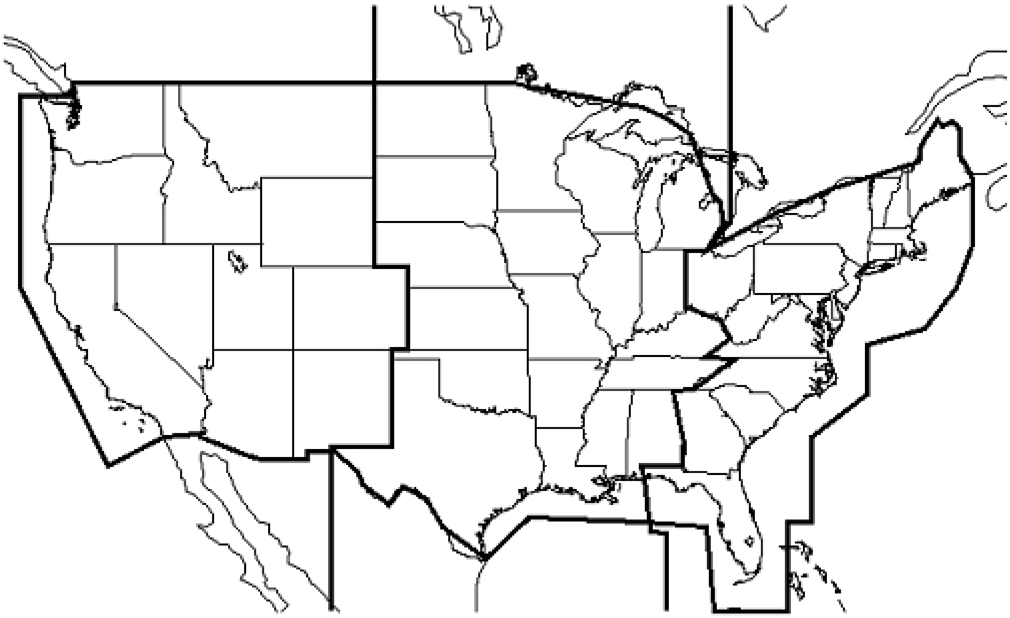
3.1.4 West

The West region extends westward from the Central region to the coastal waters of Washington, Oregon, and California, as shown in Figure 3.1.

3.1.5 Northeast Corridor

The Northeast Corridor region covers the north east U.S. This region corresponds to the verification region of the Convective Weather Demonstration exercise.

Figure 3.1 Map of U.S. showing the regions used for verification of the convective products. The National region is the entire domain represented by the solid black surrounding the U.S., the East region extends from the Mississippi Valley to the east, the Central region extends westward from the East region to a north/south line located from eastern Montana to western Texas, and the West region extends west of the Central region to the coastal waters of Washington, Oregon, and California.



3.2 Coverage

Coverage is an attribute specific to the CCFP. Within each area of convection, coverage will be identified as either Low (25 - 49%), Medium (50 - 74%) or High (75 - 100%). Lines of coverage shall be displayed as a solid purple line, alone or within an area of coverage. For purposes of verification, the length of the line must be 100 nm long, or greater, the width of the line must be 20nm on either side and the coverage must be 75% or greater.

3.3 Height

Height is an attribute specific to the CCFP. Within each area of convection, maximum cloud tops will be identified in one of three classes: 1.) less than 31,000 ft, 2.) 31,000?37,000 ft, 3.) more than 37,000 ft. The maximum cloud tops will be identified in a marker balloon.

3.4 Confidence

Confidence is an attribute specific to the CCFP. For each area of convection, a subjective statement of confidence is required. This parameter is the forecaster confidence that convective weather, as defined by the minimum CCFP criteria, will occur in the forecast polygon at the specified time and place. The confidence value will be identified with a marker balloon, and identified in one of three classes: 1.) Low (Less than 40%), 2.) Medium (40% - 70%), and 3.) High (Greater than 70%).

NOTE regarding confidence: the subjective opinion of the forecaster is stated in probabilistic terms (%) and is only addressed to the question of the existence of the forecast polygon that meets the minimum CCFP criteria ---regardless of any other properties of the forecast convection; i.e., for any configuration (lines and areas); for any growth rates; for any coverage; and for any category of growth/decay rate, speed/direction, or tops. The confidence is NOT a probability of occurrence unless and until an empirical probability has been calculated, post-facto, from a comparison of a substantial record of forecast confidence with actual observations.

Notice that this definition has been chosen to avoid the confusion between areal coverage and forecast probability that has been used by forecasters. A true estimate of probability can only be determined after-the-fact with empirical data, or after a long consistent record of forecasting has been accumulated. This issue has been identified by Wallace (2001), and others.

4.0 Time Increment

The dates are used to allow the users access to statistics for any period of time (e.g. day, week, month, year). Users can change any portion of the date boxes. The months that are provided to the user through the interface are dependent upon the year that the user chooses. The months available do vary by product and by year. However, the year 2000 is not an option. Data is available for April 2001 to the present, except for the CCFP, which is a seasonal forecast.

4.1 Beginning Date

The Beginning Date will default to either the previous date chosen by the user or to the earliest date for which data are available.

4.2 Ending Date

The Ending Date will default to either the previous date chosen by the user or to the latest date for which data are available.

5.0 Output

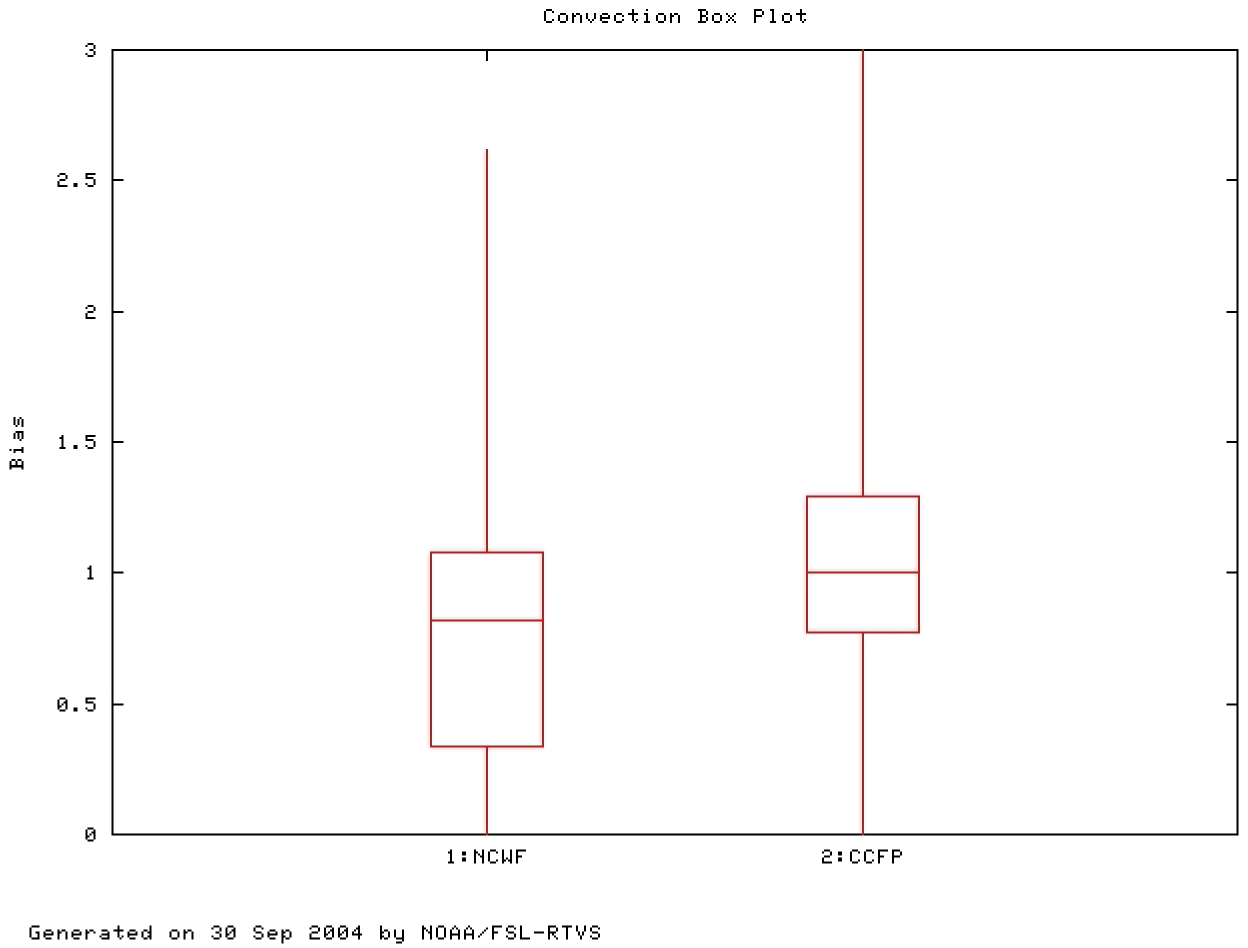
5.1 Plot Type

5.1.1 Box Plot

The box portion of a box plot encloses the region between the 0.25th and the 0.75th quantiles (i.e., the middle 50% of the distribution), and the line inside the box represents the median value, for which

50% of the values is larger and 50% is smaller. The ends of the hiskers? extending above and below the box are the minimum and maximum values. Finally, the open point inside the box represents the mean value of the statistic.

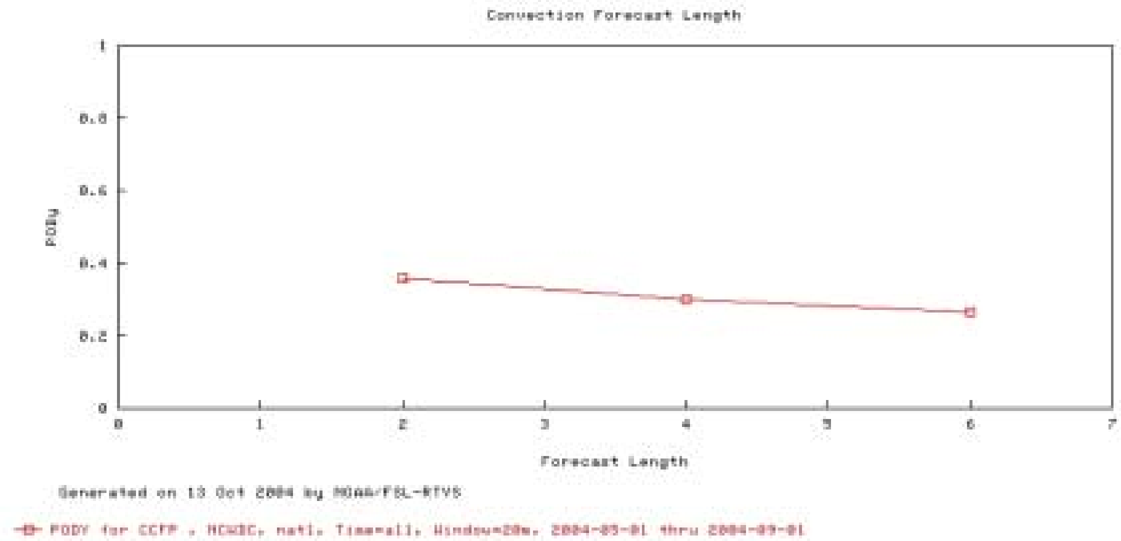
Figure 5.1 Box plot of the NCWF and CCFP forecasts, both verified with the NCWF Detection Field for the period 1 April 2001 - 30 September 2004.



5.1.2 Forecast Length

The forecast length plot allows users to plot a statistic for the forecast's various lead-times. An example of the forecast length plot is shown in Figure 5.2, which shows the PODy scores for the 2-, 4-, and 6-h lead time forecasts of the CCFP.

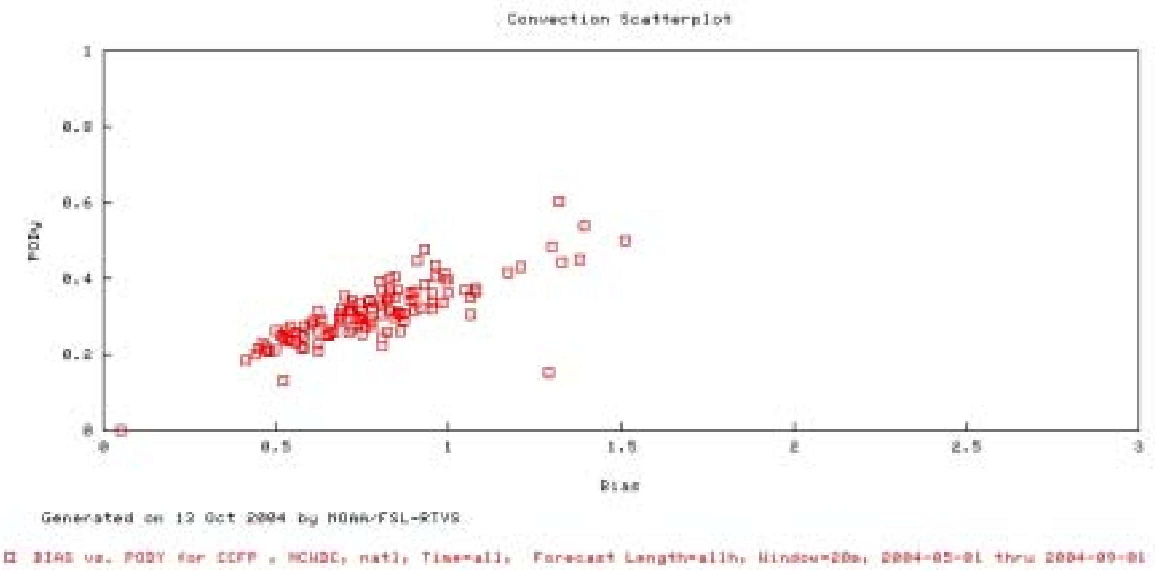
Figure 5.2 Forecast length plot of PODy for the CCFP from 1 May - 1 September 2004.



5.1.3 Scatter Plot

An example of a scatterplot is shown in Figure 5.3. Each dot on the scatterplot represents one specific forecast period. The number of forecast periods displayed on the plots is determined by the time period chosen by the user (in this case the time period chosen was from 1 May - 1 September 2004).

Figure 5.3 Scatterplot of PODy vs Bias for the CCFP using the NCWD-derived coverage (%) field from 1 May ?1 September 2004. PODs range from 0 ?1.0.



5.1.4 Summary Table

The summary table allows users to view data for all statistics (described in Section 5.2) for each individual date in the selected date range. An example of a summary table is shown in Figure 5.4.

Figure 5.4 Summary table for the CCFP, verified with the NCWD-derived coverage field (%), for the period 1 - 10 May 2004.

Statistical Summary Table

CCFP , NCWDC, natl, Time=all, Forecast Length=allh, Window=20m, 2004-05-01 thru 2004-05-10

Date	YY	YN	NY	NN	PODy	PODn	FAR	CSI	TSS	Heidke	Gilbert	Bias	% Area	Areaeff
2004-05-01	463550	437661	507005	22203944	0.478	0.981	0.49	0.33	0.458	0.47	0.31	0.93	3.01	12.51
2004-05-02	262821	272137	325842	22751360	0.446	0.988	0.51	0.31	0.435	0.46	0.29	0.91	2.26	19.71
2004-05-03	209477	246690	137158	23018835	0.604	0.989	0.54	0.35	0.594	0.51	0.35	1.32	1.93	31.28
2004-05-04	0	1950	37754	23572456	0.000	1.000	1.00	0.00	-0.000	-0.00	-0.00	0.05	0.01	0.00
2004-05-05	12561	36995	83378	23479226	0.131	0.996	0.75	0.09	0.129	0.17	0.09	0.52	0.21	62.38
2004-05-06	19349	147382	110398	23334831	0.149	0.994	0.88	0.07	0.143	0.13	0.07	1.29	0.71	21.09
2004-05-07	141587	266958	264023	22919590	0.349	0.988	0.67	0.20	0.337	0.33	0.20	1.06	1.81	19.23
2004-05-08	198760	263576	441603	22706201	0.310	0.989	0.57	0.22	0.299	0.35	0.21	0.72	1.95	15.65
2004-05-09	292723	426193	507398	22385046	0.366	0.981	0.59	0.24	0.347	0.37	0.22	0.90	3.04	12.02
2004-05-10	248894	429214	845167	22088885	0.227	0.981	0.63	0.16	0.208	0.25	0.15	0.62	2.87	7.92

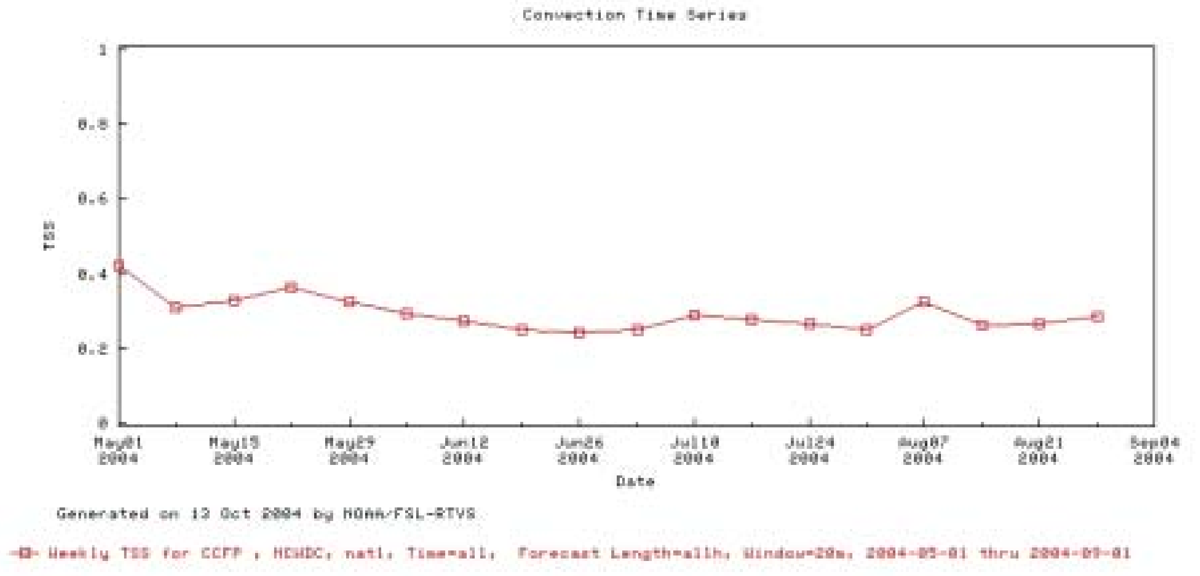
Totals

YY	YN	NY	NN	PODy	PODn	FAR	CSI	TSS	Heidke	Gilbert	Bias	% Area	Areaeff
1849742	2548956	3259724	228463176	0.362	0.989	0.58	0.24	0.351	0.38	0.23	0.86	1.86	19.43

5.1.5 Time Series

An example of a time series plot is shown in Figure 5.5. The time period for display on the X-axis can be daily, weekly, or monthly.

Figure 5.5 Time series plot for weekly TSS for the CCFP forecast, verified with the NCWD-derived coverage field (%) for the period 1 May - 1 September 2004.



5.2 Statistic

The forecast/observation pairs used to create the skill scores are summarized in Table 5.1. The rows in the table represent the forecasts, the columns in the table represent the observations, and the elements in the cells represent the counts of forecast/observation pairs.

Table 5.1 Contingency table for evaluation of dichotomous (Yes/No) forecasts. Elements in the cells are the counts of forecast-observation pairs.

Forecast	Observation		Total
	Yes	No	
Yes	YY	YN	YY+YN
No	NY	NN	NY+NN
Total	YY+NY	YN+NN	YY+YN+NY+NN

See the **Verification Techniques** section for additional details.

5.2.1 Area Efficiency

Area Efficiency is the ratio of PODy to Percent Area. It is the percent of the forecast domain where convection is expected to occur.

Area Eff = (PODy * 100) / (Percent Area)

5.2.2 Bias

Bias is the ratio of the number of Yes forecasts to the number of Yes observations. It is a measure of over- or under-forecasting.

Bias = (YY + YN) / (YY + NY)

5.2.3 CSI

CSI is the proportion of hits that were either forecast or observed. It is also known as Threat Score.

CSI = YY / (YY + NY + YN)

5.2.4 FAR

FAR is the proportion of Yes forecasts that were not accurate.

FAR = YN /(YY + YN)

5.2.5 Gilbert

Gilbert Skill Score is the Critical Success Index (CSI) corrected for the number of hits expected by chance.

Gilbert = (YY - C2) / (YY - C2) + YN + NY

where C2 = (YY + YN)*(YY + NY) / N

5.2.6 Heidke

Heidke Skill Score (Heidke) is the percent accurate (YesYes or NoNo) corrected by the number expected to be accurate by chance.

Heidke = (YY + NN - C1) / (N - C1)

where N = YY + NY + YN + NN
C1 = [(YY + YN)*{YY + NY)] + [(NY + NN)*(YN + NN)] / N

5.2.7 Percent Area

Percent Area is the percentage of the forecast domain's area where convection is expected to occur. It is the percent of the total area that had a Yes forecast.

% Area = (Forecast Area / Total Area) * 100

5.2.8 PODn

The PODn is defined as the probability of detecting a NO event. It is the proportion of NO events that were correctly forecast.

PODn = NN / (NN + YN)

5.2.9 PODy

The PODy is defined as the probability of detecting a YES event. It is the proportion of YES events that were correctly forecast.

PODy = YY / (YY + NY)

5.210 TSS

The True Skill Statistic, (Doswell et al 1990) is a measure of the ability of the forecasts to discriminate between "Yes" and "No" observations. It is also known as the Hanssen-Kuipers discrimination statistic (Wilks 1995).

TSS = PODy + PODn - 1

6.0 References

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附件二

Operational Turbulence On-line User Manual

Version 20041014

Table of Contents

1.0 Product

The product refers to the type of forecast being verified. There are five possible selections available to the user for operational turbulence, including Airmen's Meteorological Advisories (AIRMETs), AIRMETs without amendments, Significant Meteorological Advisories (SIGMETs), SIGMETs without cancellations, and Graphical Turbulence Guide (GTG).

1.1 AIRMETs

AIRMETs (National Weather Service 1991) are issued at four standard times each day and are valid for 6 hours. AIRMETs are issued when moderate icing, turbulence, or reduced visibility conditions occur or are expected to occur and affect an area of at least 3,000 square miles. The AIRMETs issued by the Aviation Weather Center (AWC) must follow specified NWS guidelines and formats. For example, the 3,000 square mile minimum area requirement may inhibit forecasters from issuing AIRMETs for smaller regions.

The textual AIRMET describes an outline of a forecast region using line segments that connect a series of location identifiers. The weather content described in the body of the AIRMET frequently includes complex altitude information describing the projected volume, such as a base or top that slopes from one part of the AIRMET to another. This information is not easily decoded and, in fact, the shapes of the volumes are often simplified during the decoding process.

AIRMET amendments are issued as necessary to describe weather conditions not originally forecast or to describe the cessation of conditions meeting the AIRMET criteria. In theory, the amended AIRMETs supersedes the scheduled AIRMET or a previously issued amendment.

AIRMETS are amended as necessary due to changing weather conditions or issuance/cancellation of a SIGMET. When AIRMETs are chosen, the valid time of the scheduled AIRMET or previous amendment is adjusted to reflect the time that was stated in the new amendment. Therefore, when an amendment is issued, the beginning time of the amendment becomes the ending time of the scheduled AIRMET or previous amendment. For this selection, all AIRMETs, scheduled and amended, are considered in this verification procedure.

[Verification Techniques for Turbulence AIRMETs]

1.2 AIRMETs without Amendments

When AIRMETs without amendments are chosen, no adjustments are made to the valid time of the scheduled AIRMET. For this selection, only the scheduled AIRMETs are used in the verification process.

1.3 SIGMETs

SIGMETs are weather advisories issued concerning weather significant to the safety of all aircraft. SIGMET advisories cover severe and extreme turbulence, severe icing, and widespread dust or sandstorms that reduce visibility to less than 3 miles.

When selecting SIGMETs, adjustments are made to the VALID UNTIL time of the SIGMET so that the VALID UNTIL statement reflects the time that the forecast was cancelled.

[Verification Techniques for Turbulence SIGMETs]

1.4 SIGMETs without Cancellations

When selecting SIGMET without cancellations, no adjustments to the forecast VALID UNTIL statements are made. Therefore, in this case, the valid period for the SIGMET is assumed to be from the time the SIGMET is issued until the time indicated by the VALID UNTIL statement (which is generally a 4-h period).

1.5 Graphical Turbulence Guidance (GTG)

The GTG (Graphical Turbulence Guidance) is an automatically generated turbulence product that predicts the location and intensity of turbulence over the continental United States (CONUS). The GTG was developed by the NCAR Turbulence Product Development Team, sponsored by the Federal Aviation Administration's Aviation Weather Research Program, and implemented by the National Weather Service Aviation Weather Center as a supplement to turbulence AIRMETs and SIGMETs.

The GTG ingests the full resolution 20 km hybrid B RUC model, domestic pilot reports (including those received directly from Northwest Airlines), and one-minute lightning data. The GTG uses this data to produce an upper-level clear air turbulence (CAT) prediction. The algorithm uses a "fuzzy logic" computational scheme, which assigns a weighting function to several operationally used and tested turbulence forecasting tools.

[Verification Techniques for GTG]

2.0 Observation

Direct instrumental measurements as well as voice pilot reports (PIREPs) may be used as observations, which are required for forecast verification. Although not all airplanes are equipped with all sensors, some that may be employed measure vertical-acceleration (g), eddy-dissipation-rate (edr, a measure of turbulence), water vapor (vapor), and vertical-gust (vg).

2.1 PIREPs (Pilot Flight Reports)

Numerous problems with using PIREPs for verification of turbulence products have been identified and documented by Schwartz (1996), Kelsch and Wharton (1996), and Brown et al. (1997). For example, negative PIREPs are limited in frequency since pilots are required to report the existence of turbulence conditions (Yes report), but not necessarily their absence. In addition, 1.) the distribution of turbulence reports is more indicative of air traffic routes than the true distribution of the weather phenomena; 2.) the turbulence reports are subjective and often related to the size of the aircraft encountering the phenomena; and 3.) severe evernts are undersample since aircraft avoid areas of moderate and extreme weather events once the location of the weather is identified by other pilots.

Despite these problems, PIREPs remain the best data currently available for verifying turbulence forecasts, and they are used to verify all turbulence products. The majority of the PIREPs are reported between the hours of 1200 and 0200 UTC (Brown et al., 1997). All PIREPs that report any turbulence severity (e.g., light reports and greater) are included in the verification. Negative reports, where the pilot directly reports "No Turbulence" are infrequent, but are included in the verification process.

2.1 NC PIREPs (Non-Convective Pilot Flight Reports)

When NC PIREPs is chosen from the menu, only those PIREPs located outside of convective regions are used in the verification. To determine an NCPIREP, the PIREP must be located a distance of 20-km from a lightning strike that occurred within a 40-minute window surrounding the PIREP valid time.

3.0 Stratification

3.1 Region

Statistics are generated for four specific regions. Each of the regions has been defined to follow AWC requirements.

3.1.1 National

The boundary surrounding the U.S., shown in Figure 3.1, is an example of the National region used to evaluate the turbulence products. The coastal waters are included in the area computation, but forecast/observation pairs are not generated for the coastal waters.

3.1.2 East

The East region is located eastward from a north/south line extending from the Great Lakes through the Tennessee Valley to the Gulf Coast, as shown in Figure 3.1.

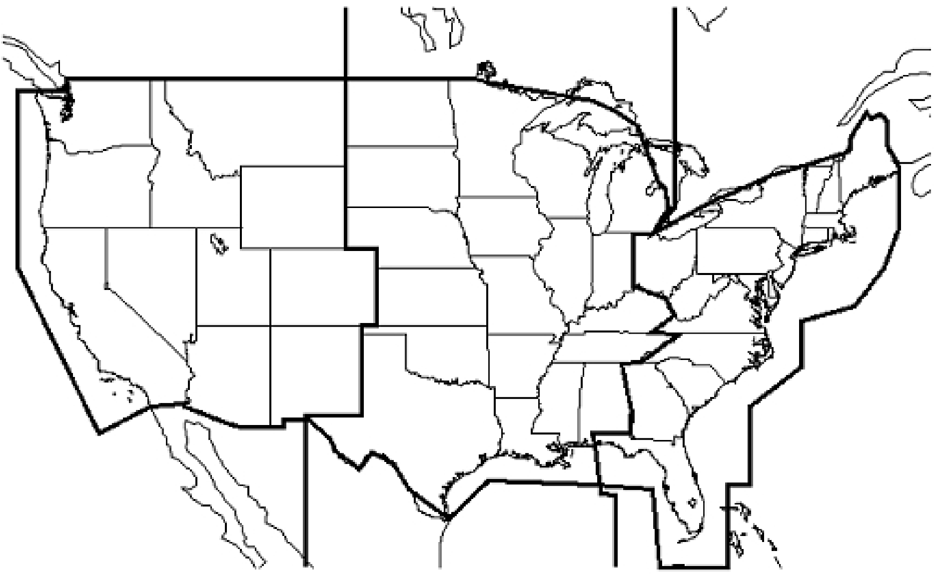
3.1.3 Central

The Central region extends west from the Eastern region to a north/south line located east of the Dakotas, Colorado, and New Mexico, as shown in Figure 3.1.

3.1.4 West

The West region extends westward from the Central region to the coastal waters of Washington, Oregon, and California, as shown in Figure 3.1.

Figure 3.1 Map of U.S. showing the regions used for verification of the turbulence products. The National region is the entire domain represented by the solid black surrounding the U.S., the East region extends from the Mississippi Valley to the east, the Central region extends westward from the East region to a north/south line located from eastern Montana to western Texas, and the West region extends west of the Central region to the coastal waters of Washington, Oregon, and California.



3.2 Flight Level

The flight level refers to the altitudes where the forecast and observations are evaluated. Stratification by flight level allows forecasts to be evaluated at higher or lower altitudes. The flight level options vary by product. For GTG, only 20,000-40,000 ft are available, for AIRMETs, options include 0-40,000 and 20,000-40,000 ft, and for SIGMETs the 0-40,000 ft level is available.

3.3 Threshold Values

The GTG product is verified using sever different threshold values: 0.06, 0.125, 0.15, 0.25, 0.375, 0.5, and 0.625. Each threshold is used to determine whether the turbulence forecast is a Yes or No. For example, any value greater than or equal to the specified threshold value would be considered a Yes forecast. Any value less than the specified threshold value would be considered a No forecast.

4.0 Time Increment

The Beginning and Ending Dates are used to allow the users access to statistics for any period of time (e.g. day, week, month, year). Users can change any portion of the date boxes. The months that are provided to the user through the interface are dependent upon the year that the user chooses.

4.1 Beginning Date

The Beginning Date will default to either the previous date chosen by the user or to the earliest date for which data are available.

4.2 Ending Date

The Ending Date will default to either the previous date chosen by the user or to the latest date for which data are available.

4.3 Valid Time

When valid time is chosen, users can choose to access statistics for: i) one particular valid time between 0000 and 2300 UTC where the forecast/observation pairs generated for the AIRMETs (either with or without amendments as selected by the product) are computed using PIREPs or NC PIREPs valid over the 2-h window that surrounds the valid time, or ii) for ALL hours, where the forecast/observation pairs (with or without amendments) are combined over the time period chosen.

4.4 Issue Time

When issue time is chosen, users can choose: i) one scheduled AIRMET period (e.g. 0145), where the AIRMETs (with or without amendments as selected by the product) are verified using 6 h of PIREPs or NC PIREPs, or ii) for All hours, where the forecast/observation pairs generated for the AIRMETs (with or without amendments as selected by the product) are combined for all hours over the time period chosen.

5.0 Output

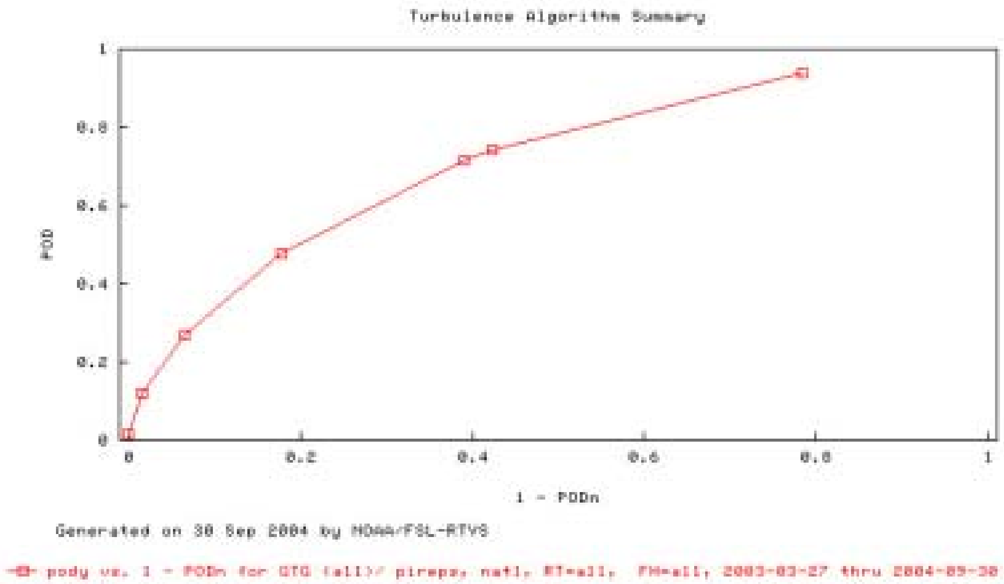
Not all output types are available for all products. AIRMETs (and AIRMETs without amendments) by Issue Time do not have height series and scatter plot options.

5.1 Plot Type

5.1.1 Algorithm Summary

The algorithm summary allows the user to plot various statistics for the selected time period. Options for the x-axis include 1-PODn, % Area, and % Volume. On the y-axis, the user can choose from the available statistics, including Explicit PODn, MOG PODy, PODy, and TSS. An example of an algorithm summary plot is shown in Figure 5.1.

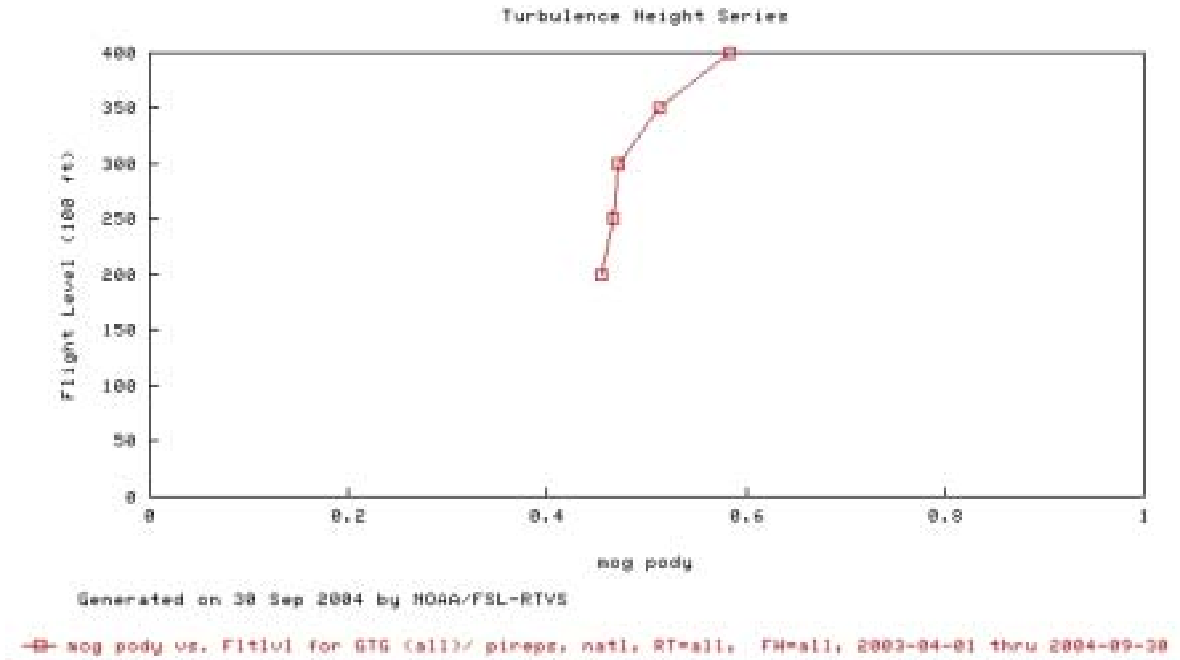
Figure 5.1 Algorithm summary plot of 1-PODn (x-axis) versus PODy (y-axis) for GTG for the time period of 27 March 2003 through 30 September 2004. Each dot on the plot represents the value for a different threshold.



5.1.2 Height Series

An example of a height series plot is shown in Figure 5.2. Statistics for turbulence are generated from 0 - 40,000 ft and 20,000-40,000 ft and displayed at 5,000 ft intervals. The statistic is always located along the X-axis with the flight level presented along the Y-axis.

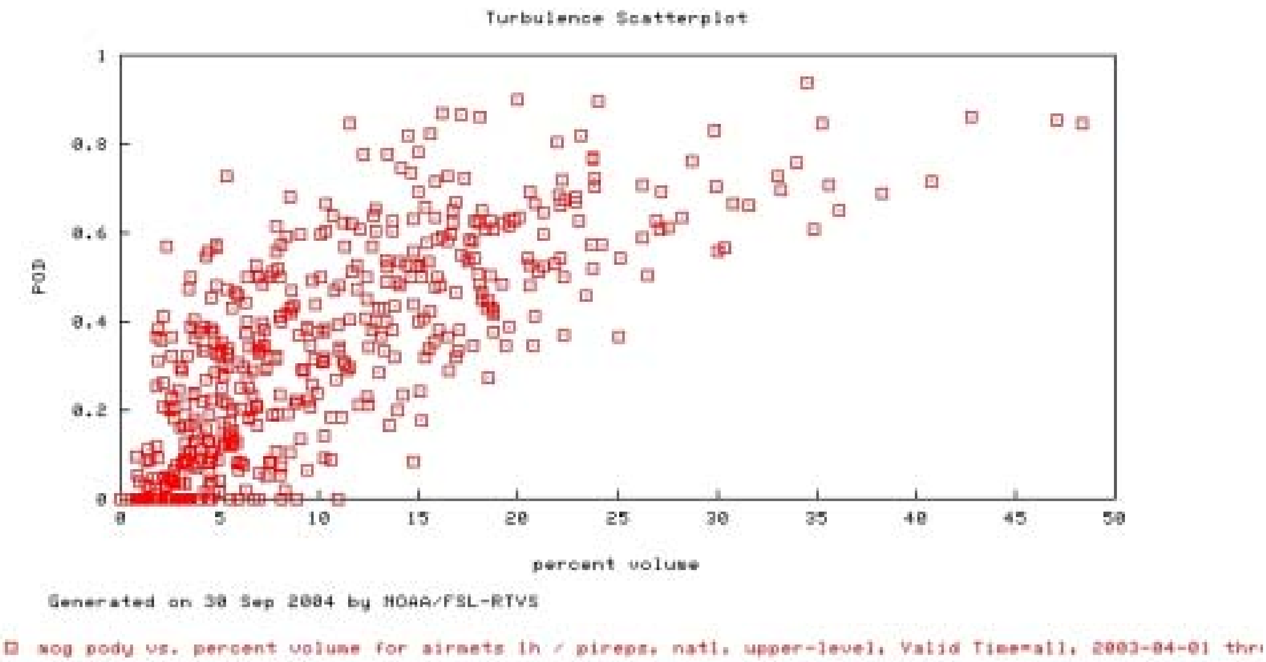
Figure 5.2 Height series plot of MOG PODy for the turbulence GTG forecast using PIREPs from 1 April 2003?30 September 2004. Heights are listed in 5,000 ft intervals from 0 to 40,000 ft and PODs range from 0 ?1.0.



5.1.3 Scatter Plot

An example of a scatterplot is shown in Figure 5.3. Each dot on the scatterplot represents one specific forecast period. The number of forecast periods displayed on the plots is determined by the time period chosen by the user (in this case the time period chosen was from 1 April 2003 - 30 September 2004).

Figure 5.3 Scatterplot of % Vol vs MOG PODy (square) for the turbulence AIRMETs using PIREPs from 1 April 2003 ?30 September 2004. PODs range from 0 ?1.0 and % Volume from 0 ?60%.



5.1.4 Summary Table

The summary table allows users to view data for all statistics (described in Section 5.2) for each individual date in the selected date range. An example of the summary table output is shown in Figure 5.4.

Figure 5.4 Summary table for the turbulence AIRMETs using PIREPs from 20 ?30 September 2004.

Statistical Summary Table

for airmets_1h / pireps, natl, upper-level, Valid Time=all, 2004-09-20 thru 2004-09-30

Date	PODy	PODn	MOG_PODy	TSS	% Area	% Vol
2004-09-20	0.413	0.698	0.400	0.111	22.81	14.98
2004-09-21	0.387	0.798	0.432	0.185	21.05	12.99
2004-09-22	0.022	0.910	0.000	-0.068	9.76	5.51
2004-09-23	0.650	0.836	0.574	0.486	12.53	8.12
2004-09-24	0.133	0.923	0.250	0.057	9.89	6.43
2004-09-25	0.412	0.890	0.373	0.301	11.28	6.32
2004-09-26	0.591	0.770	0.500	0.361	15.86	6.97
2004-09-27	0.140	0.936	0.077	0.075	10.13	6.17
2004-09-28	0.391	0.914	0.323	0.305	5.51	3.36
2004-09-29	0.439	0.893	0.559	0.332	6.69	4.36

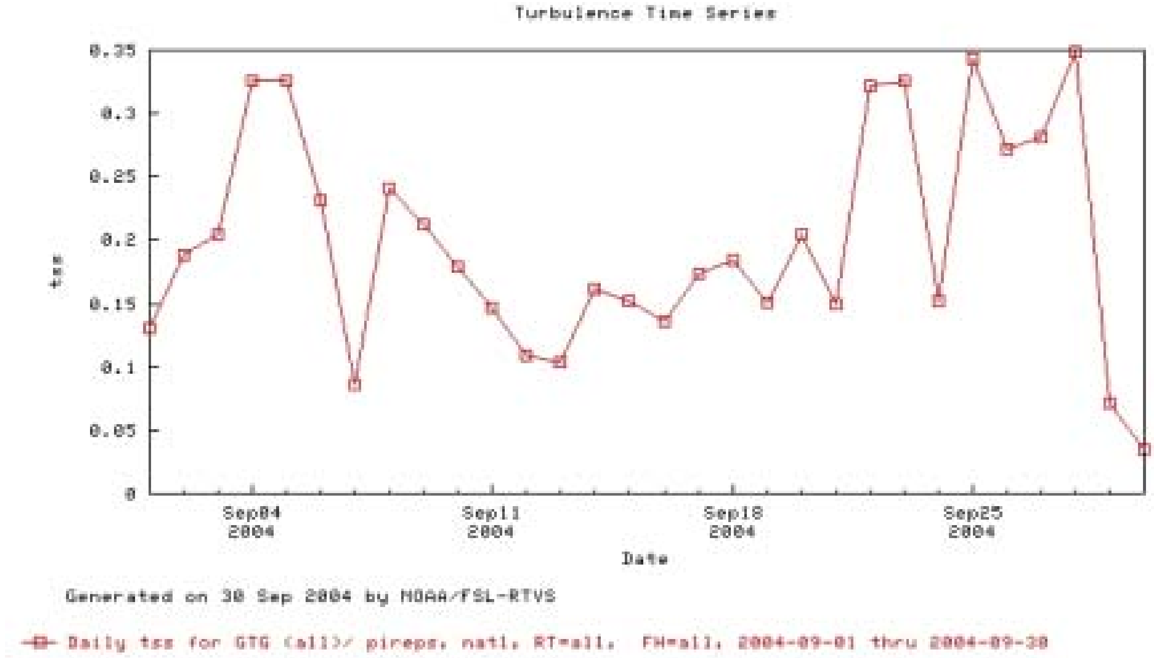
Totals

PODy	PODn	MOG_PODy	TSS	avg(% Area)	avg(% Vol)
0.418	0.869	0.378	0.288	12.77	7.65

5.1.5 Time Series

An example of a time series plot is shown in Figure 5.5. The time period for display on the X-axis can be daily, weekly, monthly, or quarterly. It is best that the weekly period be chosen when using PIREPs as verification to ensure that enough PIREPs are used to evaluate the forecasts.

Figure 5.5 Time series plot of daily TSS for the turbulence GTG using PIREPs from 1 ?30 September 2004.



5.2 Statistic

The forecast/observation pairs used to create the skill scores are summarized in Table 5.1. The rows in the table represent the forecasts, the columns in the table represent the observations, and the elements in the cells represent the counts of forecast/observation pairs. Note that the counts in the verification table are observation-based (i.e., the sum of the counts is the total number of Yes and No PIREPs that were included in the analysis) and not all AIRMETs may be verified.

Table 5.1 Contingency table for evaluation of dichotomous (Yes/No) forecasts. Elements in the cells are the counts of forecast-observation pairs.

Forecast	Observation		Total
	Yes	No	
Yes	YY	YN	YY+YN
No	NY	NN	NY+NN
Total	YY+NY	YN+NN	YY+YN+NY+NN

See the **Verification Techniques** section for additional details.

The following statistics are available for the turbulence verification. It should be noted that all statistics are not available for all products. For both AIRMETs, the following statistics are available: Explicit PODn, MOG PODn, MOG PODy, PODn, PODy, TSS. For SIGMETs, only MSOG PODn and MSOG PODy are available. For GTG, available statistics include Explicit PODn, MOG PODy, PODy, and TSS.

5.2.1 Explicit PODn

The Explicit PODn is defined as the probability of a NO event. It is the proportion of observed NO events that were correctly forecast. All PIREPs that explicitly report an absence of turbulence in the atmosphere are used to compute the Explicit PODn.

Explicit PODn = NN / (NN + YN)

5.2.2 MOG PODn

The MOG PODn is defined as the probability of detecting a NO event. It is the proportion of observed NO events that were correctly forecast. All PIREPs that explicitly report NO turbulence and those PIREPs with an intensity of light or light to moderate turbulence are used to compute the MOG PODn.

MOG PODn = NN / (NN + YN)

5.2.3 MOG PODy

The MOG PODy is defined as the probability of detecting a moderate or greater (MOG) YES event. It is the proportion of observed events that were correctly forecast. The PIREPs or NC PIREPs with an intensity of moderate or greater turbulence are used to compute the MOG PODy.

MOG PODy = YY / (YY + NY)

5.2.4 MSOG PODn

The MSOG PODn is defined as the probability of detecting a NO event. It is the proportion of NO events that were correctly forecast. PIREPs that explicitly report NO turbulence and the PIREPs with an intensity of light, light-to-moderate, and moderate turbulence are used to compute the MSOG PODn.

MSOG PODn = NN / (NN + YN)

5.2.5 MSOG PODy

The MSOG PODy is defined as the probability of detecting a YES event. It is the proportion of YES events that were correctly forecast. PIREPs that had an intensity of moderate-to-severe or greater turbulence were used to compute the PODy.

MSOG PODy = YY / (YY + NY)

5.2.6 PODn

The PODn is defined as the probability of detecting a NO event. It is the proportion of NO events that were correctly forecast. All PIREPs that explicitly report NO turbulence and the PIREPs with an intensity of light turbulence are used to compute the PODn.

PODn = NN / (NN + YN)

5.2.7 PODy

The PODy is defined as the probability of detecting a YES event. It is the proportion of YES events that were correctly forecast. The PIREPs or NC PIREPs that had an intensity of light to moderate or greater turbulence were used to compute the PODy.

PODy = YY / (YY + NY)

5.2.8 TSS

The True Skill Statistic, (Doswell et al 1990) is a measure of the ability of the forecasts to discriminate between "Yes" and "No" observations. It is also known as the Hanssen-Kuipers discrimination statistic (Wilks 1995).

TSS = PODy + PODn - 1

6.0 References

Brown, B.G., G. Thompson, R.T. Bruintjes, R. Bullock, and T. Kane, 1997: Intercomparison of in-flight icing algorithms. Part II: Statistical verification results. *Wea. Forecasting*, 12, 890-914.

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附件三

Operational Icing On-line User Manual

Version 20041014

Table of Contents

1.0 Product

The product refers to the type of forecast being verified. There are six possible selections available to the user for operational icing, including Airmen's Meteorological Advisories (AIRMETs), AIRMETs without Amendments, Significant Meteorological Advisories (SIGMETs), SIGMETs without cancellations, Current Icing Potential (CIP), and Forecast Icing Potential (FIP).

1.1 AIRMETs

AIRMETs (National Weather Service 1991) are issued at four standard times each day and are valid for 6 hours. AIRMETs are issued when moderate icing, turbulence, or reduced visibility conditions occur or are expected to occur and affect an area of at least 3,000 square miles. The AIRMETs issued by the Aviation Weather Center (AWC) must follow specified NWS guidelines and formats. For example, the 3,000 square mile minimum area requirement may inhibit forecasters from issuing AIRMETs for smaller regions.

The textual AIRMET describes an outline of a forecast region using line segments that connect a series of location identifiers. The weather content described in the body of the AIRMET frequently includes complex altitude information describing the projected volume, such as a base or top that slopes from one part of the AIRMET to another. This information is not easily decoded and, in fact, the shapes of the volumes are often simplified during the decoding process.

AIRMET amendments are issued as necessary to describe weather conditions not originally forecast or to describe the cessation of conditions meeting the AIRMET criteria. In theory, the amended AIRMETs supersedes the scheduled AIRMET or a previously issued amendment.

AIRMETS are amended as necessary due to changing weather conditions or issuance/cancellation of a SIGMET. When AIRMETs are chosen, the valid time of the scheduled AIRMET or previous amendment is adjusted to reflect the time that was stated in the new amendment. Therefore, when an amendment is issued, the beginning time of the amendment becomes the ending time of the scheduled AIRMET or previous amendment. For this selection, all AIRMETs, scheduled and amended, are considered in this verification procedure.

Verification Techniques for Icing AIRMETs

1.2 AIRMETs without Amendments

When AIRMETs without amendments are chosen, no adjustments are made to the valid time of the scheduled AIRMET. For this selection, only the scheduled AIRMETs are used in the verification process.

1.3 SIGMETs

SIGMETs are weather advisories issued concerning weather significant to the safety of all aircraft. SIGMET advisories cover severe and extreme icing, severe icing, and widespread dust or sandstorms that reduce visibility to less than 3 miles.

When selecting SIGMETs, adjustments are made to the VALID UNTIL time of the SIGMET so that the VALID UNTIL statement reflects the time that the forecast was cancelled.

Verification Techniques for Icing SIGMETs

1.4 SIGMETs without Cancellations

When selecting SIGMET without cancellations, no adjustments to the forecast VALID UNTIL statements are made. Therefore, in this case, the valid period for the SIGMET is assumed to be from the time the SIGMET is issued until the time indicated by the VALID UNTIL statement (which is generally a 4-h period).

1.5 CIP (Current Icing Potential)

The Current Icing Potential (CIP) product combines sensor and numerical model data to provide a three-dimensional diagnosis of the icing environment. Currently CIP output consists of a likelihood field ranging from 0 (no icing) to 100 (certain icing). While this is not yet calibrated as a true probability value, CIP has value in pointing out real differences in the likelihood of encountering icing at a given location. More technical details of the science behind the CIP product are found here.

CIP depicts both "all" icing and "SLD" (supercooled large droplet) icing conditions. SLD icing conditions are characterized by water drops larger than 50 micrometers (diameter) which includes freezing drizzle and freezing rain aloft. These conditions are outside the icing certification envelopes and have been demonstrated to be a particularly hazardous condition to some aircraft. Thus the information can be valuable for flight planning.

Verification Techniques for CIP

1.6 FIP (Forecast Icing Potential)

The Forecast Icing Potential (FIP) is an automatically-generated index of forecast icing potential. The FIP was developed at the National Center for Atmospheric Research (NCAR) under the Federal Aviation Administrations' (FAA) Aviation Weather Research Program (AWRP). The FIP examines numerical weather prediction model output to calculate the potential for in-flight aircraft icing conditions. This icing potential demonstrates the confidence that an atmospheric location, represented by a three-dimensional model grid box, will contain supercooled liquid water that is likely to form ice on an aircraft. The algorithm analyzes the model output from a vertical column, determines the cloud top and base heights, checks for embedded cloud layers, and identifies a precipitation type. Once the likely locations of clouds and precipitation are found, the physical icing situation is determined, and a fuzzy logic method is used to determine the icing potential. The fuzzy logic interest maps are based on clues from the model output reflecting relevance to the presence of icing. After the information is extracted, the interest maps are combined in a manner that reflects their significance for icing, given the physical situation present. The entire model domain is examined and the result is a three-dimensional depiction of the icing potential at the model valid time.

The FIP uses output from the 20-km Rapid Update Cycle (RUC; hybrid-b coordinate), which is run hourly at the National Center for Environmental Prediction and generates forecasts with one-hour granularity out to three hours. Every three hours the model generates forecasts out to twelve hours. The model has a full cloud physics package, much of which was developed at NCAR under FAA support. The microphysics parameterization predicts five water species including two liquid (cloud water and rain) and three ice (cloud ice, snow, and graupel) categories. Numerous fields from the model are used to determine the icing potential at each model grid box.

Verification Techniques for FIP

2.0 Observation

2.1 PIREPs (Pilot Flight Reports)

Numerous problems with using PIREPs for verification of icing products have been identified and documented by Schwartz (1996), Kelsch and Wharton (1996), and Brown et al. (1997). For example, negative PIREPs are limited in frequency since pilots are required to report the existence of icing conditions (Yes report), but not necessarily their absence. In addition, 1.) the distribution of icing reports is more indicative of air traffic routes than the true distribution of the weather phenomena; 2.) the icing reports are subjective and often related to the size of the aircraft encountering the phenomena; and 3.) severe evernts are undersample since aircraft avoid areas of moderate and extreme weather events once the location of the weather is identified by other pilots.

Despite these problems, PIREPs remain the best data currently available for verifying icing forecasts, and they are used to verify all icing products. The majority of the PIREPs are reported between the hours of 1200 and 0200 UTC (Brown et al., 1997). All PIREPs that report any icing severity (e.g., light reports and greater) are included in the verification. Negative reports, where the pilot directly reports "No icing" are infrequent, but are included in the verification process.

2.2 NC PIREPs (Non-Convective Pilot Flight Reports)

When NC PIREPs is chosen from the menu, only those PIREPs located outside of convective regions are used in the verification. To determine an NC PIREP, the PIREP must be located a distance of 20-km from a lightning strike that occurred within a 40-minute window surrounding the PIREP valid time.

3.0 Stratification

3.1 Region

Statistics are generated for four specific regions. Each of the regions has been defined to follow AWC requirements.

3.1.1 National

The boundary surrounding the U.S., shown in Figure 3.1, is an example of the National region used to evaluate the icing products. The coastal waters are included in the area computation, but forecast/observation pairs are not generated for the coastal waters.

3.1.2 East

The East region is located eastward from a north/south line extending from the Great Lakes through the Tennessee Valley to the Gulf Coast, as shown in Figure 3.1.

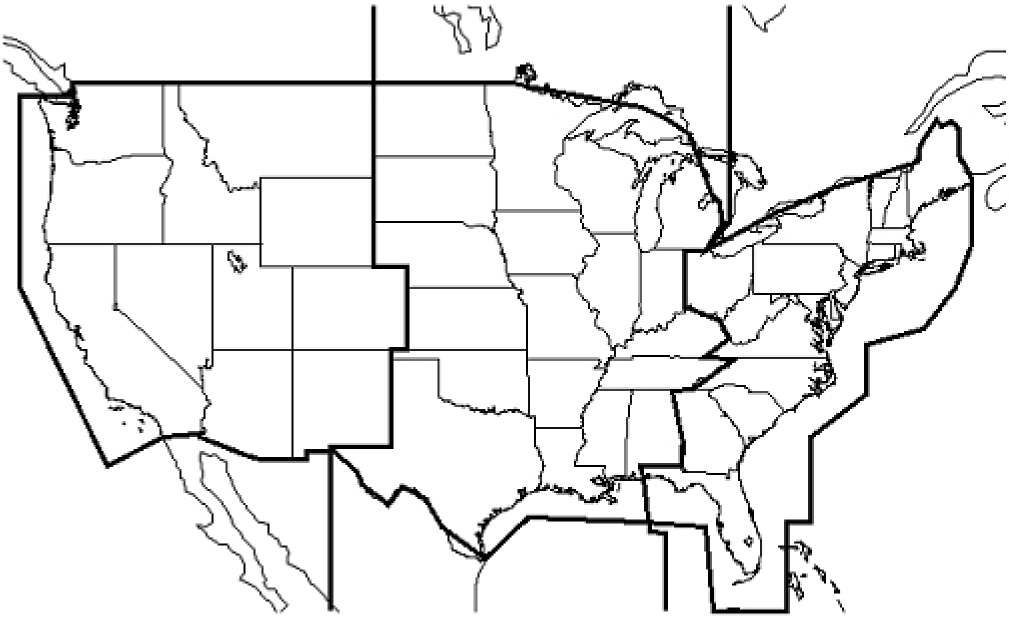
3.1.3 Central

The Central region extends west from the Eastern region to a north/south line located east of the Dakotas, Colorado, and New Mexico, as shown in Figure 3.1.

3.1.4 West

The West region extends westward from the Central region to the coastal waters of Washington, Oregon, and California, as shown in Figure 3.1.

Figure 3.1 Map of U.S. showing the regions used for verification of the icing products. The National region is the entire domain represented by the solid black surrounding the U.S., the East region extends from the Mississippi Valley to the east, the Central region extends westward from the East region to a north/south line located from eastern Montana to western Texas, and the West region extends west of the Central region to the coastal waters of Washington, Oregon, and California.



3.2 Threshold Values

CIP and FIP are both verified using six different threshold values: 0.02, 0.15, 0.25, 0.45, 0.65, and 0.85. Each threshold is used to determine whether the icing forecast is a Yes or No. For example, any value greater than or equal to the specified threshold value would be considered a Yes forecast. Any value less than the specified threshold value would be considered a No forecast.

4.0 Time Increment

The Beginning and Ending Dates are used to allow the users access to statistics for any period of time (e.g. day, week, month, year). Users can change any portion of the date boxes. The months that are provided to the user through the interface are dependent upon the year that the user chooses.

4.1 Beginning Date

The Beginning Date will default to either the previous date chosen by the user or to the earliest date for which data are available.

4.2 Ending Date

The Ending Date will default to either the previous date chosen by the user or to the latest date for which data are available.

4.3 Valid Time

When valid time is chosen, users can choose to access statistics for: i) one particular valid time between 0000 and 2300 UTC where the forecast/observation pairs generated for the AIRMETs (either with or without amendments as selected by the product) are computed using PIREPs or NC PIREPs valid over the 2-h window that surrounds the valid time, or ii) for ALL hours, where the forecast/observation pairs (with or without amendments) are combined over the time period chosen.

4.4 Issue Time

When issue time is chosen, users can choose: i) one scheduled AIRMET period (e.g. 0145), where the AIRMETs (with or without amendments as selected by the product) are verified using 6 h of PIREPs or NC PIREPs, or ii) for All hours, where the forecast/observation pairs generated for the AIRMETs (with or without amendments as selected by the product) are combined for all hours over the time period chosen.

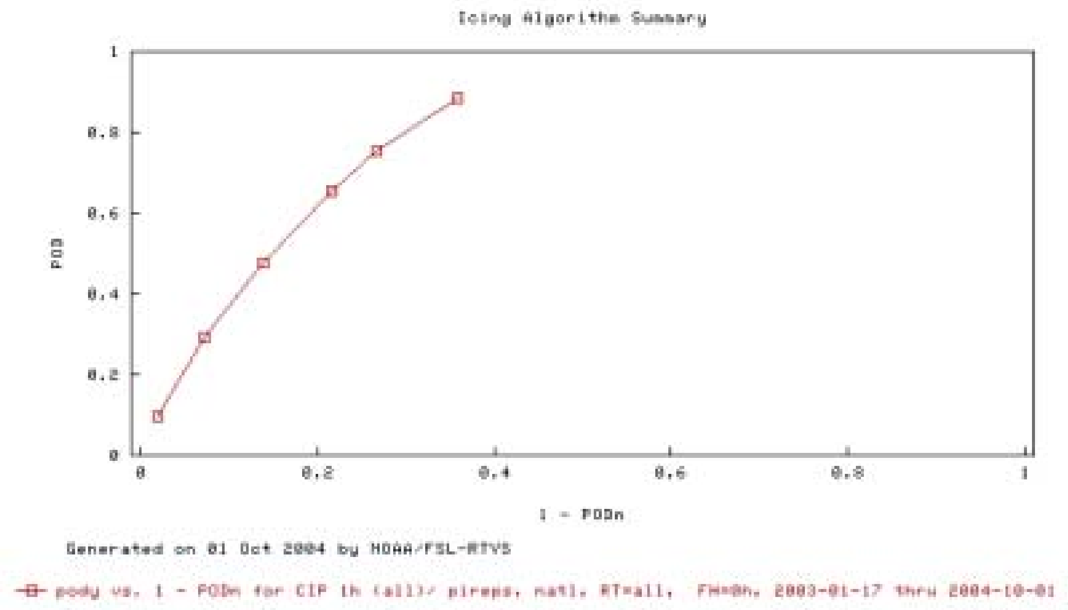
5.0 Output

5.1 Plot Type

5.1.1 Algorithm Summary

The algorithm summary allows the user to plot various statistics for the selected time period. Options for the x-axis include 1-PODn, % Area, and % Volume. On the y-axis, the user can choose from the available statistics, including Explicit PODn, MOG PODn, MOG PODy, PODn, PODy, and TSS. An example of an algorithm summary plot is shown in Figure 5.1.

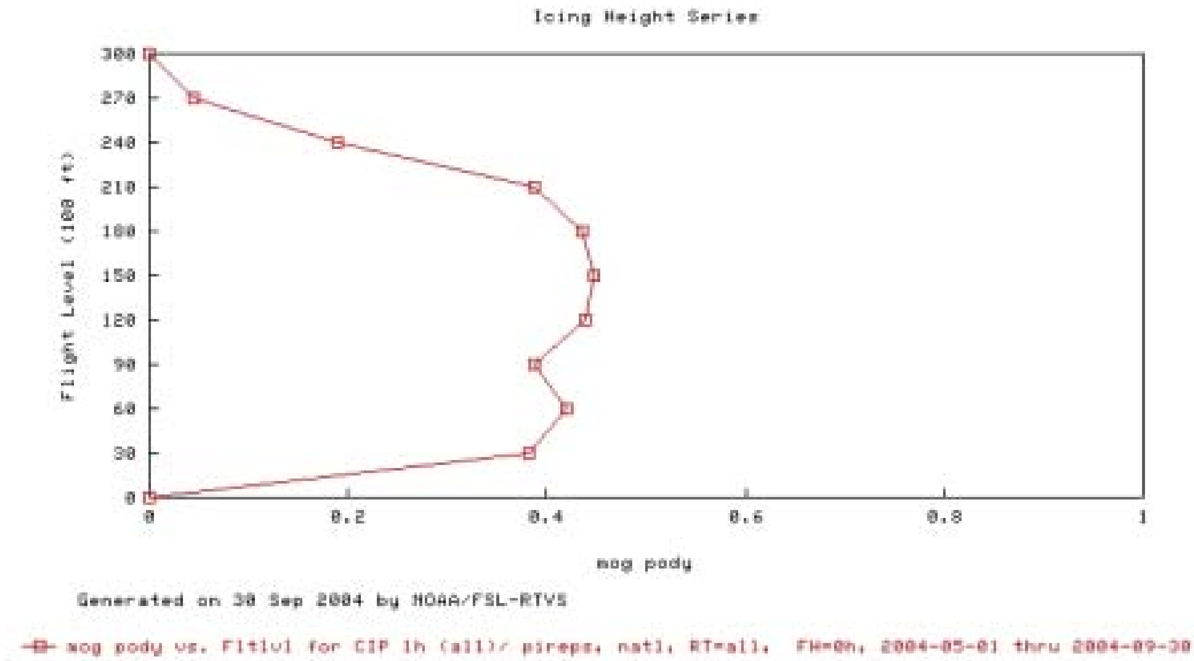
Figure 5.1 Algorithm summary plot of 1-PODn (x-axis) versus PODy (y-axis) for CIP for the time period of 17 January 2003 through 30 September 2004. Each dot on the plot represents the value for a different threshold.



5.1.2 Height Series

An example of a height series plot is shown in Figure 5.2. Statistics for icing are generated from 0 - 30,000 ft and displayed at 3,000 ft intervals. The statistic is always located along the X-axis with the flight level presented along the Y-axis.

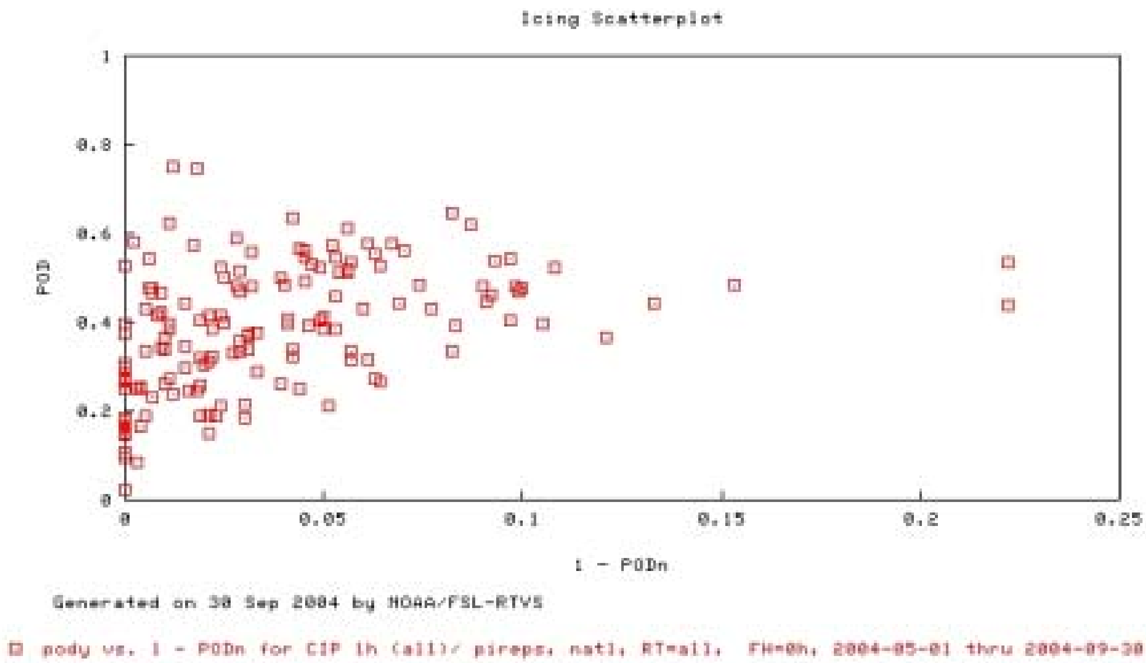
Figure 5.2 Height series plot of MOG PODy for the icing CIP forecast using PIREPs from 1 May ?30 September 2004. Heights are listed in 5,000 ft intervals from 0 to 30,000 ft and PODs range from 0 ?1.0.



5.1.3 Scatter Plot

An example of a scatterplot is shown in Figure 5.3. Each dot on the scatterplot represents one specific forecast period. The number of forecast periods displayed on the plots is determined by the time period chosen by the user (in this case the time period chosen was from 1 May - 31 March 2001).

Figure 5.3 Scatterplot of PODy vs 1-PODn(square) for the icing CIP using PIREPs from 1 May ?31 March 2001. PODs range from 0 ?1.0



5.1.4 Summary Table

The summary table allows users to view data for all statistics (described in Section 5.2) for each individual date in the selected date range.

Figure 5.4 Summary table for the icing CIP using NC-PIREPs from 20 ?30 September 2004.

Statistical Summary Table
for CIP_1h (all)/ ncpireps, natl, RT=all, FH=0h, 2004-09-20 thru 2004-09-30

Date	PODy	PODn	MOG_PODy	TSS	avg(% Area)	avg(% Vol)
2004-09-20	0.316	0.939	0.315	0.256	14.94	2.94
2004-09-21	0.432	0.940	0.394	0.372	12.08	2.17
2004-09-22	0.426	0.950	0.250	0.376	11.07	2.10
2004-09-23	0.333	0.943	0.357	0.276	10.57	2.06
2004-09-24	0.542	0.994	0.500	0.536	8.22	1.58
2004-09-25	0.028	1.000	0.000	0.028	7.55	1.48
2004-09-26	0.333	1.000	0.333	0.333	7.03	1.44
2004-09-27	0.178	1.000	0.212	0.178	10.72	2.21
2004-09-28	0.220	0.993	0.225	0.213	12.78	2.63
2004-09-29	0.226	0.976	0.244	0.202	8.36	1.60
2004-09-30	0.312	0.979	0.167	0.292	8.85	1.57

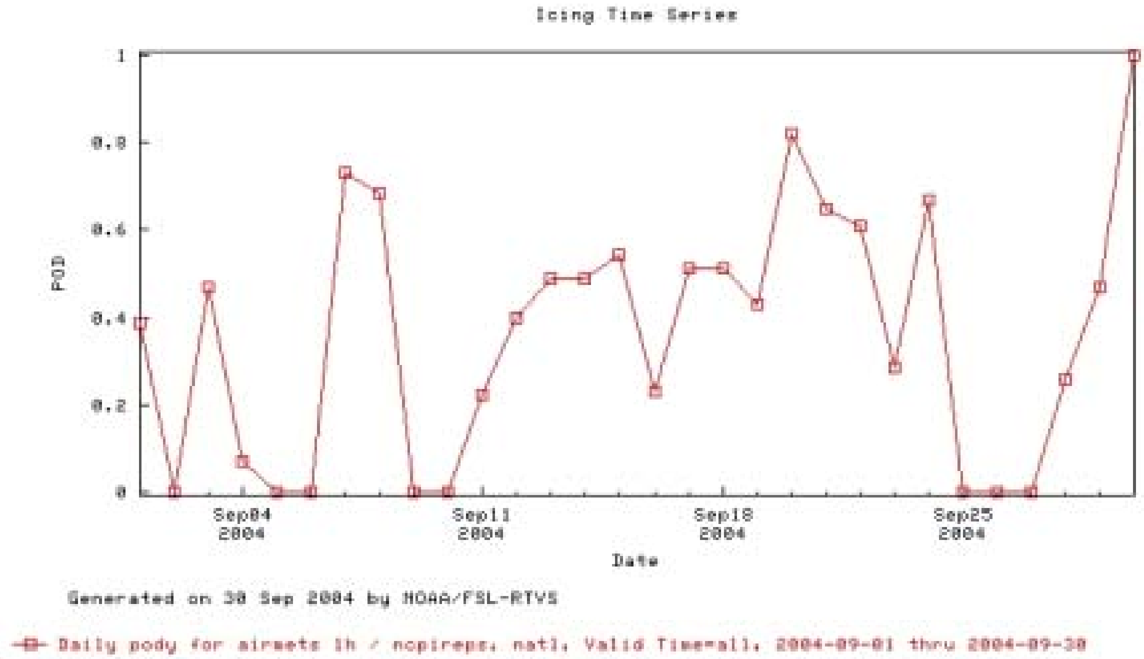
Totals

PODy	PODn	MOG_PODy	TSS	avg(% Area)	avg(% Vol)
0.310	0.973	0.282	0.283	10.42	2.03

5.1.5 Time Series

An example of a time series plot is shown in Figure 5.5. The time period for display on the X-axis can be daily, weekly, monthly, or quarterly. It is best that the weekly period be chosen when using PIREPs as verification to ensure that enough PIREPs are used to evaluate the forecasts.

Figure 5.5 Time series plot of daily PODy (square) for the icing AIRMETs using PIREPs for the period 1 - 30 September 2004. PODs range from 0 ?1.0.



5.2 Statistic

The forecast/observation pairs used to create the skill scores are summarized in Table 5.1. The rows in the table represent the forecasts, the columns in the table represent the observations, and the elements in the cells represent the counts of forecast/observation pairs. Note that the counts in the verification table are observation-based (i.e., the sum of the counts is the total number of Yes and No PIREPs that were included in the analysis) and not all AIRMETs may be verified.

Table 5.1 Contingency table for evaluation of dichotomous (Yes/No) forecasts. Elements in the cells are the counts of forecast-observation pairs.

Forecast	Observation		Total
	Yes	No	
Yes	YY	YN	YY+YN
No	NY	NN	NY+NN
Total	YY+NY	YN+NN	YY+YN+NY+NN

See the **Verification Techniques** section for additional details.

The following statistics are available for the icing verification. It should be noted that all statistics are not available for all products. For both AIRMETs, the following statistics are available: Clear

Above PODn, Explicit PODn, MOG PODn, MOG PODy, PODn, PODy, TSS. For SIGMETs, only MSOG PODn and MSOG PODy are available. For both CIP and FIP, the statistics available are Explicit PODn, MOG PODy, PODy, and TSS.

5.2.1 Clear Above PODn

The Clear Above PODn is defined as the probability of detecting a NO event when there are clear skies above. PIREPs that include a clear above comment in the remarks section are used to compute a clear above PODn by assigning a NO observation from the base of the clear above remark up to 30,000 ft.

Clear Above PODn = NN / (NN + YN)

5.2.2 Explicit PODn

The Explicit PODn is defined as the probability of a NO event. It is the proportion of observed NO events that were correctly forecast.

Explicit PODn = NN / (NN + YN)

5.2.3 MOG PODn

The MOG PODn is defined as the probability of detecting a NO event. It is the proportion of observed NO events that were correctly forecast. All PIREPs that explicitly report NO icing and those PIREPs with an intensity of light or light to moderate icing are used to compute the MOG PODn.

MOG PODn = NN / (NN + YN)

5.2.4 MOG PODy

The MOG PODy is defined as the probability of detecting a moderate or greater (MOG) YES event. It is the proportion of observed events that were correctly forecast. The PIREPs or NC PIREPs with an intensity of moderate or greater icing are used to compute the MOG PODy.

MOG PODy = YY / (YY + NY)

5.2.5 MSOG PODn

The MSOG PODn is defined as the probability of detecting a NO event. It is the proportion of NO events that were correctly forecast. PIREPs that explicitly report NO icing and the PIREPs with an intensity of light, light-to-moderate, and moderate icing are used to compute the MSOG PODn.

MSOG PODn = NN / (NN + YN)

5.2.6 MSOG PODy

The MSOG PODy is defined as the probability of detecting a YES event. It is the proportion of YES events that were correctly forecast. PIREPs that had an intensity of moderate-to-severe or greater icing were used to compute the PODy.

MSOG PODy = YY / (YY + NY)

5.2.7 PODn

The PODn is defined as the probability of detecting a NO event. It is the proportion of NO events that were correctly forecast. All PIREPs that explicitly report NO icing and the PIREPs with an intensity of light icing are used to compute the PODn.

PODn = NN / (NN + YN)

5.2.8 PODy

The PODy is defined as the probability of detecting a YES event. It is the proportion of YES events that were correctly forecast. The PIREPs or NC PIREPs that had an intensity of light to moderate or greater icing were used to compute the PODy.

PODy = YY / (YY + NY)

5.2.9 TSS

The True Skill Statistic (Doswell et al 1990) is a measure of the ability of the forecasts to discriminate between "Yes" and "No" observations. It is also known as the Hanssen-Kuipers discrimination statistic (Wilks 1995).

TSS = PODy + PODn - 1

6.0 References

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