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10 YEARS OF DAILY FORECAST VERIFICATION

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1. INTRODUCTION

The NWS Spaceflight Meteorology Group (SMG) at the Johnson Space Center (JSC) has generated daily weather forecasts for various Shuttle landing sites in the Continental United States, Europe, and Africa (*Brody et al., 1997)* (See Table 1) for over 10 years. This effort was described earlier by *Bellue and Cunningham (1990), Bellue (1993), and Bellue(1998).* SMG verifies these forecasts based on a generic set of Shuttle Weather Flight Rules, *NASA* (2001) (See Table 2), which have been simplified for the ease of verification. Elements dealing with cloud height and amount, visibility, precipitation, and wind are verified against the weather flight rule limits and combined into an Overall category. All elements must be observed or forecast "GO", i.e. exceeding the flight rule limit, to have the Overall category element be "GO". Any one element that is "NO GO" ", i.e. not exceeding the flight rule limit, makes the Overall category "NO GO".

2. BACKGROUND

SMG uses the Forecast Editor (FE) software application described by *Myers, Wehman, and Norman (1993),* which was created for the Meteorological Interactive Data Display System (MIDDS) (Rotzoll et al., 1991) to generate these daily forecasts. This software was migrated from the MIDDS to the Advanced Weather Information Processing System (AWIPS) in 2001. Daily data files are created as Comma Separated Variable (CSV) files described by *Bellue, Keehn, and Norman (1995).*

Changes in forecast codes, e.g. the addition of the FEW cloud amount category and the cloud height placement following the cloud amount, have prompted changes to the SMG forecast data collection and verification decoding scheme. The migration from system to system has prompted updates, as has the additional requirements in support of the X 38 Crew Recovery Vehicle prototype described by *Bellue and Brody (1999).* Thus, the reformatting of the data collected before these changes were made became a prerequisite to meet the goal of generating a standardized database referred to in earlier documentation of this verification effort. See *Bellue (1998).*

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Forecast data older than 1997 are being reformatted to appear like existing data to create a standardized SMG verification database. Some fields, e.g., forecaster ID, altimeter, and temperatures, from these earlier data are not available since the information was never recorded.

It was found during the process of reformatting the older data that some original 1989 data are missing. Tabulated forecast accuracy statistics had been created from the original data. Thus, these tabulated statistics are being combined with existing data to obtain an overall forecast accuracy statistic for the period of 1987 to present.

TABLE 1 SMG DAILY FORECAST SUITE
times vary with planned landing of next upcoming shuttle mission

SITE	FORECAST LEAD TIME	VERIFIES AT
TTS (KSC) Shuttle Landing Facility, FL	90 min	12Z
	30 min	23Z
	90 min	23Z
	90 min	20Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z
E28 (NOR) White Sands Space Harbor, NM	90 min	23Z
	90 min	20Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z
EDW Edwards AFB, CA	90 min	23Z
	90 min	20Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z
ZZA Zaragoza, Spain	30 min	23Z
	15 hr	23Z
	24 h	23Z
	72 hr	23Z
MRN Moron, Spain	30 min	23Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z
BEN Ben Guerir, Morocco	30 min	23Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z
BYD Banjul, The Gambia	30 min	23Z
	15 hr	23Z
	24 hr	23Z
	72 hr	23Z

3. METHODOLOGY

Daily forecasts for each site and forecast time are entered using the Daily Forecast Editor. The current process to acquire forecast data files begins

when the forecaster creates and saves the daily file on the AWIPS workstation. These files are manually transferred to the MIDDS before being downloaded manually to floppy disk. This process is done on a regular basis to free up AWIPS disk space. Data are then collected and saved into a "year" file on an office PC. Various macros are used to parse data and evaluate results based on the sites, the forecast times, and the individual forecasters. An overall "Stations" results is created, as well. All results are posted onto a separate page (worksheet) of the "Year" file. Results from each "Year" file are collected and posted to a master forecast verification file.

4. **DATABASE AND SAMPLE OUTPUT**

Table 3 lists the data header IDs for the elements of the SMG verification database. Table 4 is a sample daily file with all data elements listed. Daily files are imported directly in the "year" file, where quality control of the data is exercised whenever obvious errors occur. Once data are moved into the "year" file, various macros are employed to evaluate conditions and parse that information into appropriate worksheets. Forecast statistics are created using the decoded data.

TABLE 2 WEATHER FLIGHT RULE LIMITS ***

*** *RULES VARY BETWEEN NIGHT AND DAY AND FROM SITE TO SITE. THESE REFLECT SIMPLIFIED LIMITS FOR VERIFICATION ONLY*

Generic Weather Flight Rules	
CEILING	"GO" = 8000 ft AGL or greater
VISIBILITY	"GO" = 5 statute miles or greater
PRECIPITATION	"GO" = none within 30 nmi (including VIRGA)
CROSSWIND	"GO" = 15 kts or less
HEADWIND	"GO" = 25 kts or less
TAILWIND	"GO" = 10 kts or less
GUST SPREAD	"GO" = 10 kts or less between steady state and peak

TABLE 3 Database Headers

HEADER	DESCRIPTION
FcstDate =	Julian date of forecast or obs
ObsVT =	Valid time of observation
FcstVT =	Valid time of forecast
Site =	Site ID
c1a =	First cloud amount
c1h =	First cloud height
c2a =	Second cloud amount
c2h =	Second cloud height
c3a =	Third cloud amount
c3h =	Third cloud height
c4a =	Fourth cloud amount
c4h =	Fourth cloud height
vis =	Visibility
wx =	Weather
dir =	Wind direction
spd =	Wind Speed
peaks =	Peak wind speed
alstg =	Altimeter setting
tt =	Temperature
td =	Dew Point Temperature
remarks =	Remarks
ksc 8ths =	Eighths of cloud at the SLF
fcstr =	Forecaster initials
data ID =	ID of data assigned by FE
Date =	Date entered
Time =	Time entered
Viol =	Violations

Table 4 FORECAST EDITOR File Format - CSV- June 21, 2001

```
,,30 MINUTE FORECAST                ,,,,,,90 MINUTE FORECAST   01152 17:18:25,,,,,,,,,,,,,,,,
,,90 MIN PM FORECAST                ,,,,,,90 MIN AM FORECAST   01152 11:47:38,,,,,,,,,,,,,,,,
,FcstDate,ObsVT,FcstVT,Site,c1a,c1h,c2a,c2h,c3a,c3h,c4a,c4h,vis,wx,dir,spd,peaks,altsg,tt,td,remarks,ksc 8ths,fcstr,data
ID,Date,Time,Viol
,01152,11Z,,KSC,FEW,120,FEW,230,,,,,7,,200,03,P06,29.98,73,72,,0,DGB,A,01152,11:47:38,NNNNNNNNNNNN
,01152,11Z,,KSC,FEW,120,BKN,230,,,,,9,,210,06,P08,29.98,73,72,,0,,B,01152,13:02:33,NNNNNNNNNNN
,01152,20Z,,KSC,SCT,040,BKN,100,OVC,250,,,7,,140,09,P14,29.95,87,73,TSRA WI 30 NM  CHC G30,2,KAS,C,01152,17:17:19,NNNNNNNNNNN
,01152,20Z,,KSC,FEW,014,BKN,025,BKN,100,OVC,240,6,-TSRA,210,04,P07,30.00,73,72,TSRA WI 30 NM,5,,E,01152,20:19:18,NNNNNNNNNNN
,01152,20Z,,KSC,SCT,030,SCT,080,SCT,250,,,7,,150,09,P14,30.00,86,68,SLGT CHC TSRA WI 30 NM,,KAS,F,01151,21:34:07,NNNNNNNNNNN
,01152,20Z,,KSC,FEW,030,SCT,120,SCT,250,,,7,,150,08,P15,29.94,86,75,TSRA WI 30NM OCNL BKN020
5SHRA,0,DGB,I,01152,12:42:55,NNNNNNNNNNN
,01152,20Z,,NOR,FEW,100,,,,,,7,,270,08,P12,29.95,92,41,,,KAS,C,01152,17:18:00,NNNNNNNNNNN
,01152,20Z,,NOR,FEW,060,,,,,,,40,,090,06,P11,29.95,95,30,,,,E,01152,20:22:04,NNNNNNNNNNN
,01152,20Z,,NOR,FEW,060,,,,,,,7,,210,06,P09,29.98,88,45,,,KAS,F,01151,21:34:31,NNNNNNNNNNN
,01152,20Z,,NOR,FEW,200,,,,,,,7,,240,08,P16,29.97,90,22,,,DGB,I,01152,12:46:11,NNNNNNNNNNN
,01152,20Z,,EDW,SKC,,,,,,,,7,,210,10,P15,29.86,104,34,,,KAS,C,01152,17:18:25,NNNNNNNNNNN
,01152,20Z,,EDW,SKC,,,,,,,,45,,240,13,P20,29.84,102,34,,,,E,01152,20:22:54,NNNNNNNNNNN
,01152,20Z,,EDW,FEW,200,,,,,,,7,,220,08,P13,29.93,100,28,,,KAS,F,01151,21:34:55,NNNNNNNNNNN
,01152,20Z,,EDW,SKC,,,,,,,,7,,220,12,P22,29.98,93,34,,,DGB,I,01152,12:48:07,NNNNNNNNNNN
,01152,20Z,,ZZA,CAV,OK,,,,,,,7,,300,18,,30.03,70,46,,,,E,01152,20:23:28,NNNNNNNNNNN
,01152,20Z,,ZZA,FEW,060,SCT,250,,,,,7,,020,06,P09,30.09,72,55,SLGHT CHC TSRA WI 20 NM,,KAS,F,01151,21:31:57,NNNNNNNNNNN
,01152,20Z,,ZZA,SKC,,,,,,,,7,,340,09,P18,30.03,73,54,,,DGB,I,01152,12:52:49,NNNNNNNNNNN
,01152,20Z,,MRN,CAV,OK,,,,,,,7,,250,06,P09,30.00,77,63,,,,E,01152,21:34:13,NNNNNNNNNNN
,01152,20Z,,MRN,FEW,200,,,,,,,7,,250,06,P09,29.97,79,60,,,KAS,F,01151,21:32:25,NNNNNNNNNNN
,01152,20Z,,MRN,SKC,,,,,,,,7,,240,08,P17,29.94,95,59,,,DGB,I,01152,12:55:27,NNNNNNNNNNN
,01152,20Z,,BEN,CAV,OK,,,,,,,7,,020,06,,30.00,97,18,,,,E,01152,20:24:28,NNNNNNNNNNN
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,01152,20Z,,BYD,FEW,012,FEW,250,,,,,7,,300,08,P16,29.90,79,68,,,DGB,I,01152,13:00:47,NNNNNNNNNNN
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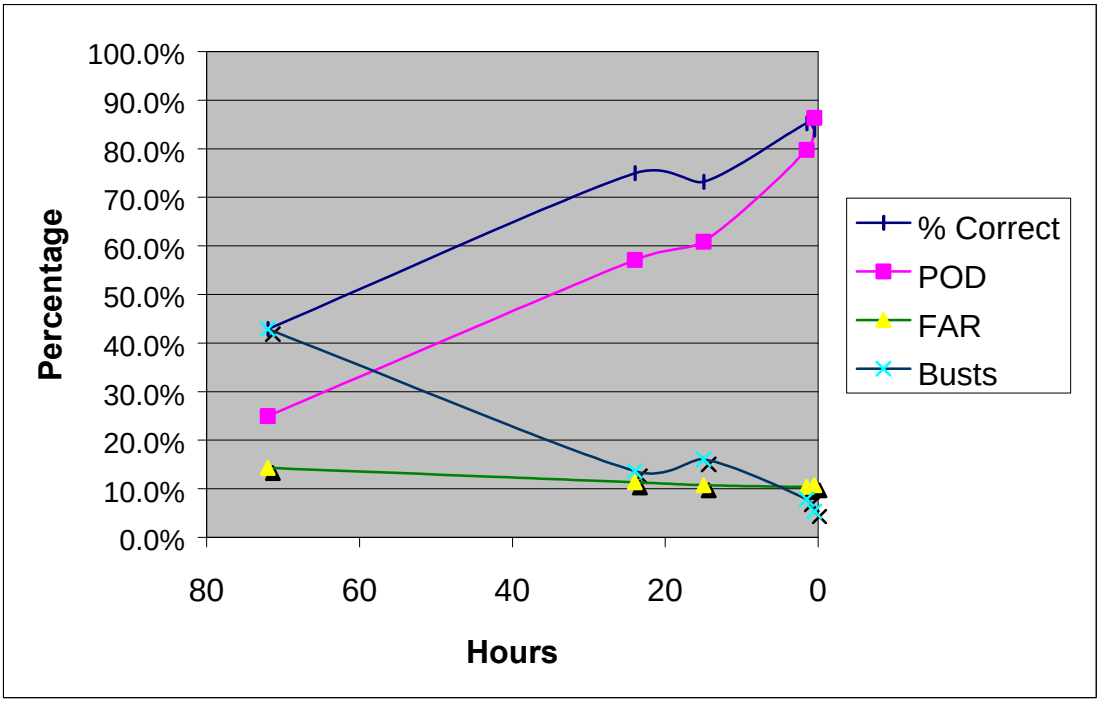

Figure 1 Graph of Forecast Accuracy Parameters for the Shuttle Landing Facility, Florida for 2001

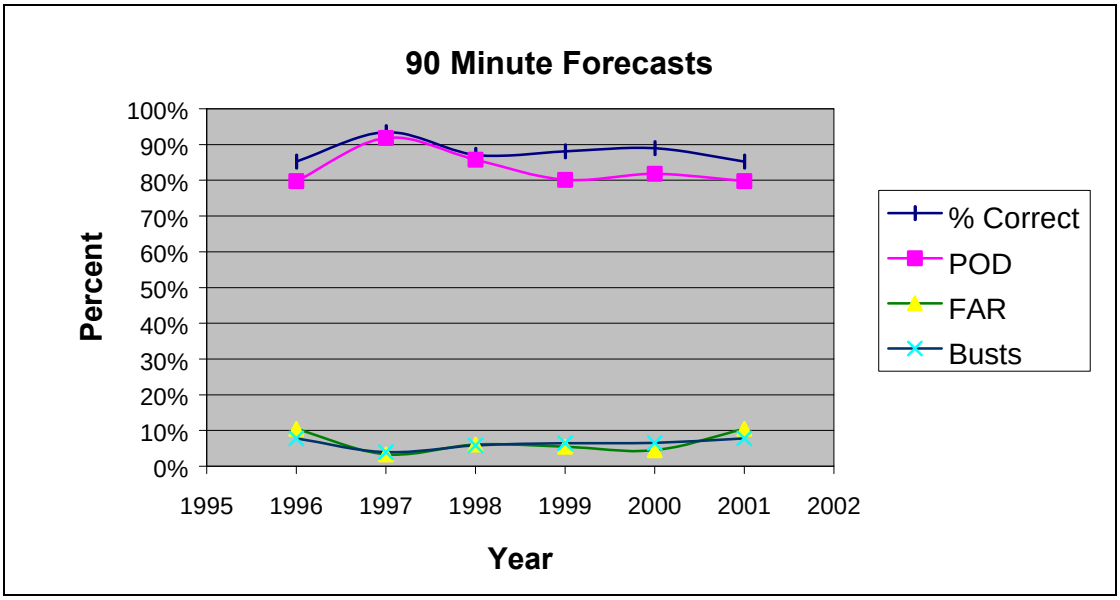

Figure 2 Graph of Forecast Accuracy Parameters for the SMG 90 Minute Forecasts generated from 1996 to Present.

It is compiled into a separate "Statistics" worksheet page and "Forecaster" worksheet page. Each site is evaluated and forecast accuracy, probability of detection (POD), false alarm rate (FAR), and catastrophic busts. Figure 1 shows statistics for the KSC Shuttle Landing Facility, Florida for the first 8 months of 2001 and is an example of a product generated for all sites. Figure 2 is shows forecast accuracy parameters of all 90 Minute Forecasts generated from 1996 to present and is an example of output created from the master file.

SMG began initialing each forecast in 1997. A "Forecaster" worksheet page was added to the "year" file such that a record of the number of forecasts generated and verified by individual forecasters is tabulated. It was found that some forecasts were not being verified even though surface observations were

routinely collected. One explanation for this occurrence has to do with SMG's mission and simulation (SIM) support. Daily simulation forecasts are suspended during direct support. Thus, some forecasts may have been produced the day before a SIM, but never verified due to a higher priority support requirement. However, there is a now concerted effort to gather all verifying observations.

The "Statistics" worksheet page depicts results for all forecasts generated and verified for all sites and shows actual numbers and percentages by forecast category and site for the year. Other worksheet pages are labeled: 1) "Forecasters", where totals of forecasts by forecaster are tabulated, 2) "WholeYear", where all forecasts and observations are collected, "DataSheet", where general information of the "year" file resides, and other sheets labeled for forecast times and sites, e.g., "24HKSCForecasts" is the sheet containing all 24 Hour forecasts and verifying observations for the Shuttle Landing Facility in Florida.

The "master" file contains worksheets of all statistics generated from the "year" files and are labeled accordingly, e.g. "2001Statistics".

4. CONCLUSIONS

Results are preliminary, but are indicative of what is being found in the mission forecast verification. Specifically, while there is increased improvement in forecast accuracy from 72 hours to 30 minutes, there remains a minor downward decline from earlier forecasts in the 15-hour forecasts. This is evident in Figure 1. This feature shows up at most all sites. Accounting for it is difficult, but may be a result of the forecaster's desire to "fine tune" the forecast.

Only data for the first seven months of 2001 are used in this study and may be the cause for the decline in accuracy for 2001 depicted in Figure 2. Verification valid times change with each mission and therefore could account for some loss in accuracy, as well.

5. FUTURE ENHANCEMENTS

Automatic entry of verifying observations into the database has not been undertaken, but should be a significant time-saver once accomplished. Additionally, incorporation of updated flight rules for each site, e.g. cloud ceilings and visibility limits of 8000 ft and 5 miles to 5000 feet and 4 miles, has not been done, but is planned for CY 2002. Verifying of winds and weather at the proposed X38 landing site in Australia has begun and will be incorporated into the next report. The final stage in the creation of the "master" database file is underway and once created, will allow quantification and stratification of all SMG forecast data. Additionally, retrieval of past observations not entered as a result of simulation and mission support will be attempted.

5. ACKNOWLEDGMENTS

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