ANALYSIS OF THE INCREASE IN NON-ROUTINE TEXT PRODUCT ISSUANCE BY WFO MILWAUKEE/SULLIVAN

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1. INTRODUCTION

The NWS mission is to provide forecasts and warnings for the protection of life and property and the enhancement of the national economy. The NWS Weather Forecast Office WFO Milwaukee/Sullivan (KMKX) serves 20 counties in southern Wisconsin and adjacent coastal waters of Lake Michigan. Providing KMKX customers with the best possible products is part of the mission. A way to measure how successful KMKX has been in meeting part of this mission is to analyze products issued by the WFO. This study presents an analysis of non-routine text products issued by KMKX. These text products include warnings (five different products), follow-up statements (two products), hydrologic (eight products), and other various products (seven products).

These products were collected, quality controlled, and tabulated in a spreadsheet, for the period from April 1994 to December 2008 by the KMKX Warning Coordination Meteorologist (WCM). The data show a substantial increase in the number of non-routine products issued by KMKX. A statistical and graphical analysis of this data shows the increase in the number of products with time, while breaking down the data into monthly, seasonal, and yearly categories. The data were also divided into three sub-categories; hydrologic, Public Information Statement (PNS) and Local Storm Report (LSR), and all other products. The number of products issued in the three sub-categories was further analyzed for additional detail.

What factors led to a five-fold increase in the number of non-routine products issued by WFO KMKX? Non-routine products are often driven by weather severity and duration and by NWS region or office policy. There are variances in the number of products issued based on active weather patterns, but trends in the data show an overall increase significant enough to draw some conclusions. The addition of three products into the dataset during the data timeframe contribute to the increase, but several other factors, including automation and various policy changes also contribute.

The quality control efforts by the KMKX WCM indicated an improvement in non-routine text product timeliness, quality, and the amount of information provided to its NWS partners and customers over the study period.

2. DATA

This study utilized archived data collected at KMKX from April 1994 to December 2008. From April 1994 to September 1996, data collected was lumped together into a number total of non-routine products issued during each month. Starting with October 1996, non-routine text products were separated by product type. The number of specific products issued by KMKX in 1996 was 19 and increased to 22 by 2006. The three products added to the data set between 1996 and 2006 were the Hazardous Weather Outlook (HWO), Local Storm Report (LSR), and Marine Weather Message (MWW).

The HWO was added in late 2001, but the HWO product was combined with the Special Weather Statement (SPS) for counting purposes. The HWO is required once per day, so this data set subtracts out one HWO product per day. The LSR product was not introduced into this data set until the 2004 fiscal year (October 2004 – September 2005). This coincided with an increased operational emphasis on issuing greater numbers of LSRs. The last product to be added to the non-routine text products in these data is the Marine Weather Message (MWW) which was added in late 2006. Table 1 shows the 22 different products used in this data set separated into warnings, follow-up statements, hydrologic products, and other non-routine text products.

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Warnings	Follow-up Statements	Hydrologic	Other
Tornado	Severe Weather	Flash Flood Warning	Hazardous Weather Outlook
Severe Thunderstorm	Marine Weather	Flash Flood Statement	Short Term Forecast
Special Marine		Flood Warning	Local Storm Report
Winter Storm		Flood Statement	Public Information Statement
Non-precipitation		Flash Flood Watch Flood Watch (River)	Record Report
		Flood Potential Outlook	Marine Weather Message
		River Statement	Special Weather Statement
		River Flooding Summary	

Table 1. Non-routine text products issued by KMKX from 2006 to present.

3. ANALYSIS OF DATA

The 22 different non-routine products were separated into the number of products issued for each category and organized into the number issued each month from October 1996 through December 2008. Adding all the products issued per month and then for each year, gave a first look at the overall increasing trend of the amount of total products issued per calendar year. Table 2 shows 1334 non-routine products were issued in 1995 and 2050 products were issued in 1996. Then from 1999 to 2003, there were as few as 1926 products in 2003 to as many as 3865 in 2000. The 3865 non-routine products issued by KMKX in 2000 was more than twice the average amount issued between 1995 and 1998. Weather patterns in 2000 were very active and many convective warnings were issued. Continuing with the overall increasing trend, each year from 2004 to 2008 saw more products issued than the highest number between the 1999 to 2003 timeframe. The most products issued for a single year in the data set was 8888 in 2008.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Total
2008	1011	1036	807	315	313	2011	1181	290	245	242	326	1111	8888
2007	328	447	602	623	326	482	399	985	359	244	230	639	5664
2006	245	198	417	415	563	586	889	594	440	449	226	486	5508
2005	377	478	354	118	342	457	478	285	337	157	286	276	3945
2004	152	175	484	101	1222	1040	445	224	58	133	53	121	4208
2003	89	104	125	174	307	232	365	177	74	56	126	97	1926
2002	95	105	192	481	222	547	247	364	181	146	80	61	2721
2001	126	331	222	420	523	585	319	423	292	273	101	109	3724
2000	136	190	149	169	752	685	479	336	373	124	156	316	3865
1999	326	96	54	272	250	513	415	268	95	61	84	119	2553
1998	132	76	138	211	197	320	155	209	82	75	93	139	1827
1997	148	185	212	138	98	233	174	86	86	77	43	86	1566
1996	247	114	88	135	153	533	213	137	41	126	117	146	2050
1995	81	52	60	83	66	132	223	258	43	51	151	134	1334
1994	-	-	-	95	22	113	122	125	97	10	43	61	-

Table 2. Non-routine products issued each month between Apr 1994 and Dec 2008

There is noticeable variability in the products issued from year to year, but overall the trend of increasing with each year is evident. In order to smooth out variability, a three year running mean was calculated. Table 3 shows a three year running mean from 1996 to 2007,

providing a better sense of how the number of products increased with time.

Year	3-Year Running Mean
2007	6687
2006	5039
2005	4554
2004	3360
2003	2952
2002	2790
2001	3437
2000	3381
1999	2748
1998	1982
1997	1814
1996	1650

Table 3. Non-routine products after a 3-year running mean calculation

3.1 New Products, Automation, and Gauges

The number of non-routine products changed from 19 in 1996 to 22 in 2006. This accounts for some of the increase of products, but there are several other factors that led to the increase. Prior to AWIPS, significant portions of the short-fuse, convective warnings and follow-up statements were manually typed. The addition of AWIPS in late 1998 allowed more automation and increased efficiency for KMKX forecasters. The AWIPS warning and statement software program (WarnGen) allowed the KMKX staff to quickly generate warnings and compose follow-up statements. The average number of follow-up statements per warning increased from an estimated one and a half to four during the 1994-2008 time period. This sizeable increase in products after the implementation of AWIPS can be seen in Table 2 starting in 1999.

The number of hydrologic products varies significantly and is dependent on the occurrence of flood or near-flood conditions at a KMKX monitored river gauge within the KMKX area of responsibility. This variability in hydrologic issuances affects the total number of non-routine products in the data set. One factor that could account for some increase in hydrologic products is the addition of river gauges, or points, during the data set. From 1994 to 2008, 10 additional river points were added, bringing the total to 42, leading to more hydrologic products issued by KMKX.

3.2 Policy Changes

Another factor that accounted for a portion of the increase in products was a policy change from the required once daily issuance of hydrologic statements and summaries at the beginning of the data set to two daily issuances and then finally four daily issuances after 2001.

The LSR product contributed to the increase in the number of products starting in 2004. Prior to 2004, LSRs were issued, but issuance was not emphasized. However, starting in 2004, the LSR product policy was changed so that more would be issued providing more information to surrounding NWS offices and customers within the KMKX area. This policy change led to a substantial increase in LSRs, thus contributing to the higher product totals within this data set. Another factor that resulted in more LSRs was the refinement of the AWIPS software program (LSR GUI) during the 2000 – 2008 time period which made it easier for the KMKX staff to generate LSRs. Of course, one needs more storm spotters to provide more severe weather spotter storm reports in order to generate more LSRs. This condition was met over the years as the number of new severe weather spotters recruited and trained totaled 10,430 in south-central and southeast Wisconsin for the time period of 1994 through 2008.

3.3 Partitioning Data

Since a large portion of the total non-routine products is comprised of LSR and hydrologic products, it was prudent to separate this data into three categories; hydrologic, PNS/LSR, and the rest of products. By separating the data into these three categories, it provided more insight into what type of non-routine products make up the total numbers for each year. An additional step was taken to separate each year into two seasons; a winter season with products from the months of October through March, and a summer season with products from the months of April through September. Figure 1 shows the number of non-routine products issued broken down into the three categories and by the winter and summer seasons, along with an estimation of precipitation in south-central and southeast Wisconsin during each season.

3.4 Data and Precipitation Relationship

As seen in Figure 1, the number of non-routine products is closely correlated with the amount of precipitation. To arrive at an estimation of precipitation, the precipitation that fell each month at the cities of Milwaukee and Madison was averaged and then broken down into winter and summer seasons. The assumption was made that averaging the precipitation that fell between the two sites would give a general estimate of precipitation that fell across the KMKX County Warning Area (CWA). Additionally, it was assumed that higher average precipitation amounts were related to a greater number of summer and winter storm systems that ultimately required more non-routine products.

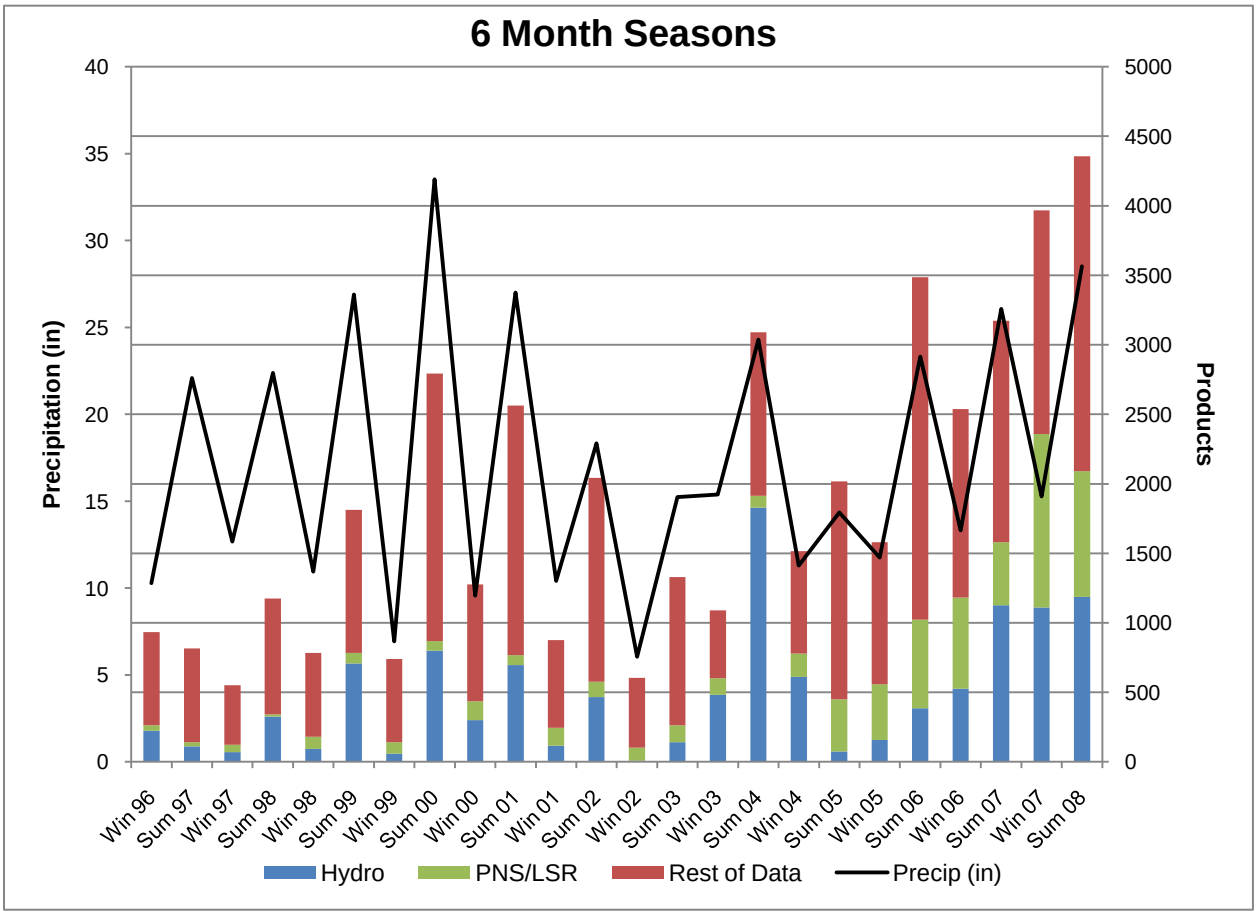

Figure 1. Six-month product totals and precipitation amounts

The overall upward trend in non-routine products is apparent in Figure 2; however, there are several increases and decreases within the 14-year period. These yearly or multi-year increases and decreases are correlated with yearly precipitation trends. For example, from 1999 to 2008 the trends for the number of products issued compared to precipitation amounts were directly correlated every year except for 2003. In addition to the trend between precipitation and the amount of products issued, there is a noticeable increase with time in the ratio between products issued versus precipitation per year.

Figure 3 shows the average yearly precipitation between Milwaukee and Madison and the number of products issued. For example, the ratio of the number of products issued per inch of precipitation between 1995 and 1999 was 58 products for every inch of precipitation, whereas between the years 2004 and 2008, there were 153 products issued for each inch of precipitation. This shows that between 2004 and 2008, nearly three times the number of products were issued for every inch of precipitation compared to the 1995 to 1999 timeframe.

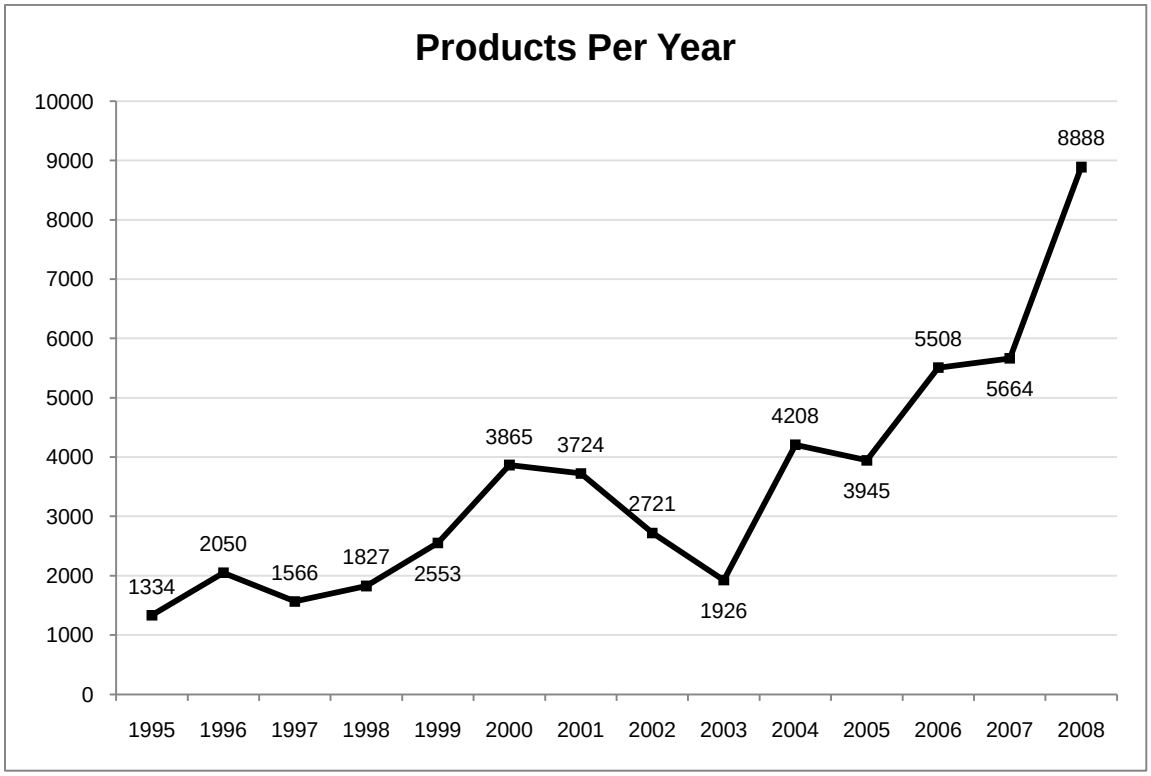

Figure 2. Non-routine products issued per year by KMKX from 1995 to 2008

Feedback from KMKX's various partners and customers concerning the increased number of non-routine products was very positive. Television meteorologists in both Milwaukee and Madison noted additional follow-up severe weather statements and LSRs made it much easier for them to brief the public in a continuous, live, severe weather mode. Likewise, Emergency Managers found the additional hydrologic flood products useful in determining planning and response activities.

3.5 Data vs. Number of Convective Warnings

As revealed in Figure 1, the 6-month summer season tended to have greater numbers of non-routine products. This was related to the number of summer convective county warnings issued; including severe thunderstorm, tornado, and flash flood warnings. During the 1994-2008 time period, there was an increase in the number of summer convective county warnings issued, from roughly 200 per year to over 400 in some years. The yearly totals of summer convective warnings issued by KMKX are shown in Table 4. In 2008, the warnings were storm-based or polygon-shaped, rather than strictly county-based as they were from 1994 through 2007. Therefore, the 2008 storm-based warnings were converted to county-based warnings in order to make comparisons more meaningful. Note there is a large yearly variation through the time period. Nonetheless, the overall increase in the number of non-routine products can partially be explained by an increase in the issuance of summer convective warnings likely caused by more convective weather events.

3.6 Effect of Staffing Level on Data

Throughout the time period of this study, the staffing levels at WFO Milwaukee varied yearly, but in general, showed a downward trend. This reduction was primarily due to NWS modernization efforts in the mid to late 1990s which reduced WFO Milwaukee staffing from 23 in 1994 to 18 by 2008. These staff members were people who generated non-routine products. Additionally, during modernization, the area of responsibility of WFO Milwaukee changed from statewide to just south-central and southeast Wisconsin, resulting in the need for fewer staff members. In spite of the staff reduction, a net increase in the number of non-routine products was still realized.

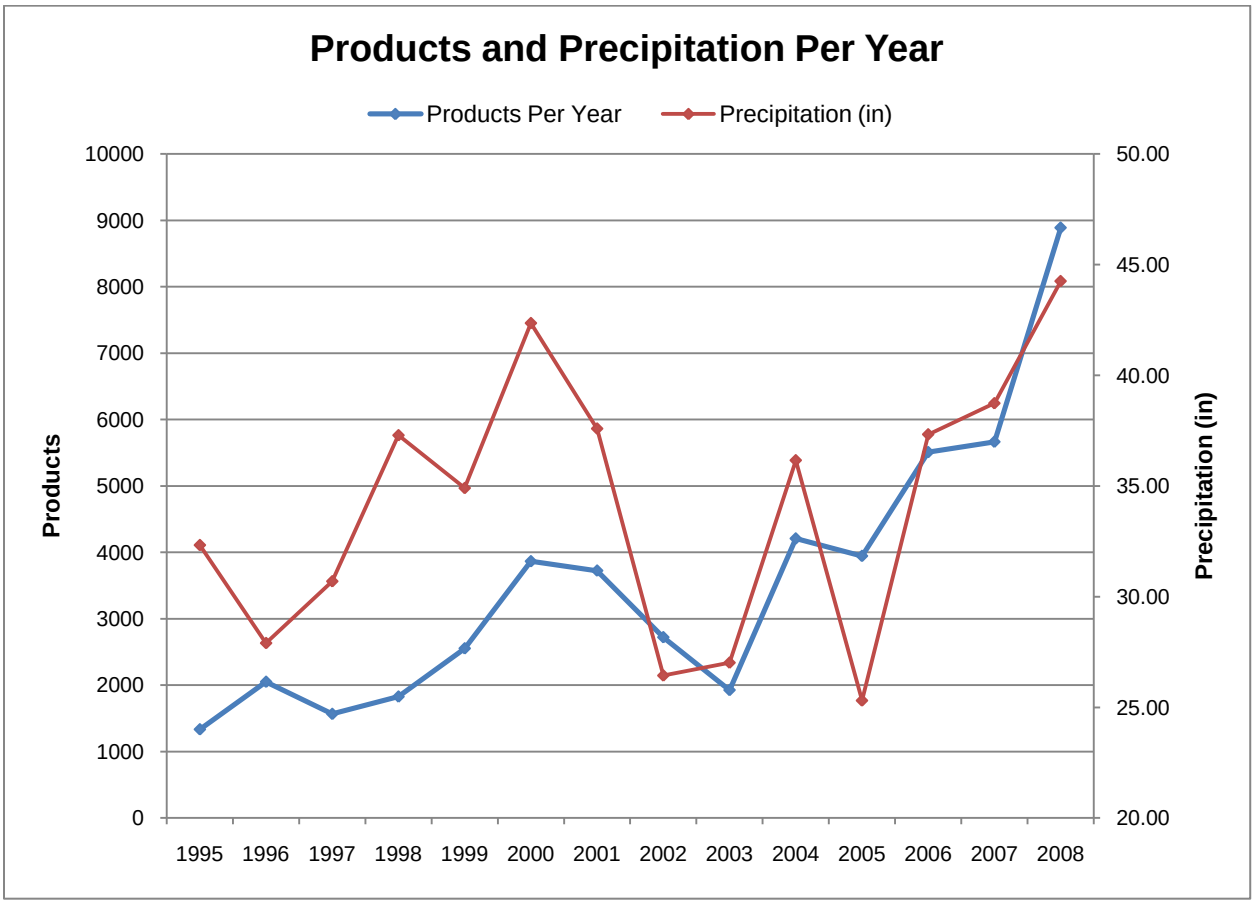

Figure 3. Products and precipitation per year from 1995 to 2008

Year	Tornado + Severe	Flash Flood	Total Warnings
2008	434*	49*	483*
2007	142	46	188
2006	393	27	420
2005	252	5	257
2004	218	27	245
2003	142	3	145
2002	162	15	177
2001	171	7	178
2000	254	80	334
1999	161	30	191
1998	199	37	236
1997	167	16	183
1996	144	18	162
1995	166	3	169
1994	190	7	197

Table 4. Convective county warnings issued by KMKX between 1994 and 2008

4. CONCLUSIONS

In 1995, KMKX issued a total of 1334 non-routine text products, while in 2008 the staff issued 8888 products. This more than five-fold increase in the total products issued per year from 1995 to 2008 was due to several reasons. Technological advances in computer hardware and software during this time period, resulted in varying degrees of automation that led to more efficient product creation. This included the implementation of the Advanced Weather Interactive System (AWIPS), and associated software applications that contained automation tools used to quickly create warnings and numerous follow-up statements. Additionally, policy changes within the NWS or locally-driven changes contributed to the creation of new, non-routine products, and increased issuance frequency of others. Natural occurring events such as significant severe weather outbreaks, widespread or long-duration flooding, and even droughts within the KMKX CWA all had an effect on the number of non-routine products issued.

Advances in hardware and software from 1994 through 2008 led to more efficient product creation. The product creation process now includes many automated aspects allowing for less time wasted. Quicker product generation provides more time for forecasters to issue other products, update current products, or spend the additional time gained browsing data. Increased automation in product creation has led to more products issued and a higher level of service, in terms of timeliness, quality, and amount of information provided to NWS partners and customers.

Policy changes within the NWS and KMKX local policy changes led to the addition of three non-routine products from 1994 to 2008 along with an increased issuance frequency of a few others. Adding the three products to the list of products contributing to the total yearly number skewed data trends. Although the overall increasing trends are skewed because of these additions, they are still products that are being issued, thus taking more of the forecaster's available. The increased frequency of hydrological products issued from once per day in the beginning of the data set timeframe to the current four times per day, along with an increased number of river points, have also added to the product totals with time. Once again, this change in policy skewed the overall trends by adding more products, but it also provided NWS customers with timelier river stage data which may be crucial to securing life and property.

The documented five-fold increase in productivity provided by KMKX staff from 1994 through 2008 ultimately provided more non-routine weather information of higher quality to users and customers. Even though some of the increase was due to increased numbers of weather events, the productivity increase is remarkable considering the staff reduction during the time of this study. This improvement in weather service should enhance the decision making process that Emergency Managers, law enforcement officials, television meteorologists, and other first-responders undergo as they deal with weather-related disasters and non-weather-related emergencies.