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Impacts of Interactive Processing Systems on the Forecasting Ability of the National Severe Storms Forecast Center (Appendix E)

Frederick R. Mosher
National Meteorological Center, National Severe Storms Severe Forecast Center, moshe774@erau.edu

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IMPACTS OF INTERACTIVE PROCESSING SYSTEMS ON THE FORECASTING ABILITY OF THE NATIONAL SEVERE STORMS FORECAST CENTER

Frederick R. Mosher
National Meteorological Center
National Severe Storms Forecast Center
Kansas City, Missouri 64106

1. INTRODUCTION

The National Severe Storms Forecast Center (NSSFC) in Kansas City has the most modern interactive processing equipment of any operational forecast office in the United States. As such, the experiences of the NSSFC serve as an indication of some of the benefits which will be derived from interactive technology when it is applied in other forecast situations. The forecast products issued by the NSSFC have become more accurate and more timely. The forecaster's efficiency and productivity has noticeably improved. These improvements have been made without the introduction of any new data sources, any major advances in meteorology, or any major advances in numerical modeling. The improvements have resulted from more rapid access to data and from having computers take over many of the housekeeping chores facing a forecaster leaving more time for meteorology.

2. BASIC ORGANIZATIONAL RESPONSIBILITIES

The National Severe Storms Forecast Center (NSSFC) in Kansas City, Missouri is responsible for forecasting severe thunderstorms and tornadoes throughout the contiguous United States. In addition to severe weather forecasting, NSSFC responsibilities include a variety of national and regional functions. The 85 meteorologists, meteorological technicians and support staff at NSSFC work round-the-clock and prepare national weather summaries, aviation forecasts and advisories to aircraft in flight.

In order to fulfill its mission, the center is divided into semi-autonomous units, each with unique responsibilities and distinctive requirements. These operational units are described in the following sections.

2.1 The Severe Local Storms Forecast Unit (SELS)

The Severe Local Storms Forecast Unit has the responsibility for the issuance of severe thunderstorm and tornado watches for the contiguous 48 states. This unit maintains a continuous watch for thunderstorm activity and issues outlooks for general and severe thunderstorms for a 24-hour, 21-hour and 16-hour period ending at 6AM CST the next day. These outlooks are disseminated in both alphanumeric and graphic forms. SELS also issues, as required, from one to six hours in advance, severe thunderstorm and tornado watches for specific areas and time periods. Watches are issued for those areas where thunderstorms are forecast to produce one or more of the following: (1) hailstones of 3/4 inch diameter or larger; (2) surface wind gusts of 50 knots or greater; and (3) tornadoes.

2.2 National Aviation Weather Advisory Unit (NAWAU); Convective SIGMET Section

This section issues bulletins to aviation interests for in-flight hazardous weather phenomena of a convective nature (e.g., thunderstorms, tornadoes) for anywhere in the contiguous 48 states. These bulletins are issued hourly and describe the location, intensity, movement and trend of convective storms. This unit also routinely plots hourly radar reports from more than 100 sites in the U.S. and Canada, keeping the SELS forecaster briefed on significant storm development as depicted by radar.

2.3 National Aviation Weather Advisory Unit (NAWAU); In-Flight and Area Forecast (FA) Section

This section issues aviation forecasts for the 48 conterminous states based on guidance products prepared by NMC as well as terminal and route forecasts prepared by the various Weather Service Forecast Offices (WSFOs). These forecasts are issued three times daily for periods up to 18 hours and include ceiling, visibility, precipitation, surface winds, icing and freezing level, turbulence and other weather elements of concern to aviation. The section also issues, as warranted, in-flight advisories on potentially hazardous flying weather for broadcast through FAA facilities both to aircraft in-flight and directly to FAA and NWS personnel.

2.4 National Public Service Unit (NPSU)

This unit prepares weather information of a national interest. Its prod-

3.2 Automated Field Operations and Services (AFOS)

NSSFC has two WSFO two-computer AFOS configurations. There are nine work stations connected to the computers. Also the NSSFC AFOS systems are augmented by two tape drives and three 10 megabytes disks. AFOS is the principal source of NMC products at NSSFC. Virtually all of the synoptic examination functions are performed on the system. A DIFAX facsimile circuit supplements the NMC products displayed at the NSSFC. AFOS is interfaced to the Eclipse system. The Eclipse/AFOS link is used to allow products generated on the Eclipse to be disseminated over AFOS.

3.3 Centralized Storm Information System (CSIS)

The CSIS is an experimental four computer network which gives the operational meteorologist interactive capability and access to digital satellite data. It was built by the Space Science and Engineering Center (SSEC) of the University of Wisconsin-Madison, and was based on the Man-Computer Interactive Data Access System (McIDAS) technology. It is build around Harris/6 computers. Each computer controls a 300-megabyte disk and a tape drive. There are four interactive imaging forecast work stations and two interactive non-imaging forecast terminals connected to CSIS.

One of the computers serves as a data base manager (DBM). Its function is to ingest data, decode it and store it in an accessible manner. The other three computers are applications processors (AP) which control the terminals. The AP's have highspeed access to the DBM.

The imaging terminals each include an Intel 8085 microprocessor used as a terminal controller. Two of the terminals have storage for 42 image frames and 13 graphic frames. The other two have 64 image frames and 32 graphic frames. The image frames are six-bit displays (64 gray shades or colors), while the graphics frames have three-bit displays (7 colors). Each terminal has a keyboard, joysticks and a data tablet for input. Output is via a CRT, a color television monitor and/or a medium speed printer. Images can be false colored (via a false color lookup table), animated, manipulated and interlaced. A cursor can be used to obtain point locations within the image in any of four interrelated coordinate systems (pixels, image pixels, latitude/longitude and location name). The graphics frames can be overlain upon the images. The non-imaging terminals consist solely of a CRT and a keyboard.

The DBM is presently connected to a GOES-East mode "A" satellite antenna system which allows direct digital satellite data ingestion. The DBM is also connected to the FAA "604" line. This teletype circuit carries conventional data (surface observations, rawinsonde observations, pilot reports, aviation forecasts). There are also two auto-dialers hooked to telephone lines. These enable CSIS to obtain Kavouras radar data and lightning location data from the summertime Bureau of Land Management network in the western U.S. There is also an interface to the NSSFC Eclipse S/230 computer. This interface gives CSIS access to AFOS and to the NOAA 360/195 computer. A dial-in telephone port and a card reader are also present. Data ingestion is either by a clock-controlled schedule or by user request from a terminal.

The APs use the data stored in the DBM to generate products. The satellite data is sectorized, enhanced (in colors) and digitally manipulated. Routines exist to treat radar data in a similar manner. Radar data can be remapped into the satellite projection. Also, composite presentations from more than one radar can be created. The "604" data can be listed, sorted, plotted, manipulated algebraically, contoured and mapped into various map projections.

One unique feature of CSIS is that it is designed to operate in a "fail-soft" mode. The hardware on all four computers is functionally identical. Only software determines whether a CPU is an AP or a DBM. Terminals can be reconnected to any CPU via a patch panel. Thus, if one or more computers fail, the system can be reconfigured through a simple change of switch settings. Total failure of CSIS is highly improbable.

3.4 Radar Receivers

Radar data is available by a number of means. Manually digitized radar observations are received over AFOS and manually plotted every hour into a national composite (because the national composite from NMC is not available in a timely fashion). Individual radar imagery can be accessed via dial-up services. CSIS has access to radar via the Kavouras network switching center in Minneapolis, Minnesota. In addition, two stand-alone NWS Radar Information Display (RADID) systems allow access to the FAA's Radar Remote Weather Display System (RRWDS) and to the Kavouras radar system.

3.5 Electronic Animation System (EAS)

The EAS is a microprocessor controlled display system that animates the satellite imagery. The heart of the system is a large double-sided disk, holding 300 tracks (images) per side. Image sequences can operate in two modes: forward and then reverse or forward only (flyback). The system has eight channels used by SELS for the layout of a watch area. The forecaster interactively lays out a watch area overlaying the satellite or radar image loop. He can interactively move the area around, change its size, etc., until it exactly covers the threatened area. The computer then takes the graphic outline and computes boundary coordinates and what cities should be included in the watch message (such as "an area 70 statute miles either side of a line from 20 miles south of Burlington, Iowa to 40 miles east-northeast of Benton Harbor, Michigan). This graphical aid has speeded up the message composition process in addition to allowing more accurate placement of watches. Current plans call for expanding this interactive graphic message aid to include types of messages which have boundaries defined by a series of city names. The forecaster would just draw the outline and the computer would pick out the appropriate cities for the message.

4.3 Timely Data Presentation

One of the major features of the CSIS was the timely access to satellite data. Prior to CSIS, the GOES data were available about 30 minutes after real time. CSIS reduced this to about three minutes. This had several impacts. The satellite data became the primary tool for monitoring current conditions which pertain to the initiation of severe weather (although the recent real time ability to ingest and loop individual or

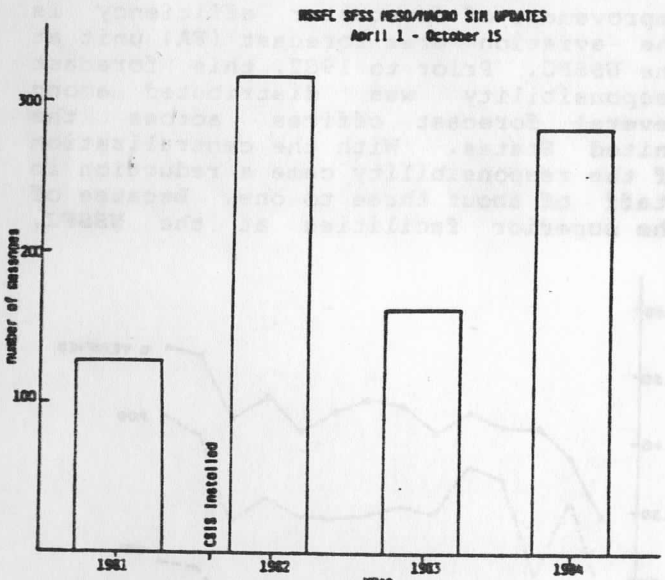

Figure 1. The number of mesoscale updates to the Satellite Interpretation Messages (SIM) issued by the NSSFC/SFSS as a function of year. The update messages provide field forecasters with a detailed interpretation of what will happen in the next 1-3 hours for rapidly developing thunderstorm situations. There was a noticeable jump in the number of messages generated after CSIS was installed.

composited radar images has caused a strong comeback in the importance of radar information). The preliminary stages of convection can now be detected sufficiently soon so that short term forecast messages can be composed and sent to the areas being affected by the convection before it has reached a dangerous stage.

One graphical example of the impact of timely data presentation has been the issuance of mesoscale updates to the Satellite Interpretation Messages (SIM) provided by the Satellite Field Services Station at the NSSFC. The Meso-Update SIMs are issued in rapidly developing thunderstorm or heavy snow situations, and provide the field forecasters with a detailed interpretation of what will happen in the next 1-3 hours. Figure 1 shows the number of Meso-Updates of SIMs issued by the NSSFC/SFSS from 1981 to 1984. Installation of CSIS in February 1982 allowed the more timely access to satellite data. There was a noticeable jump in the number of messages generated after CSIS was installed. (The dip in the figure in 1983 was due to a record drought with very little convective activity.) In addition to having a larger number of update messages, the messages also contained more local detail because of the ability of CSIS to easily access county names, city names, etc.

Another example of the benefits of timely satellite data presentation has been the number of days when the GOES has been operated in the 15 minute rapid scan (RISOP) severe storm mode. Figure 2 shows the number of days the rapid scan mode was called by the NSSFC/SFSS. With the CSIS capability to use current data, the RISOP mode was called more frequently by the forecasters.

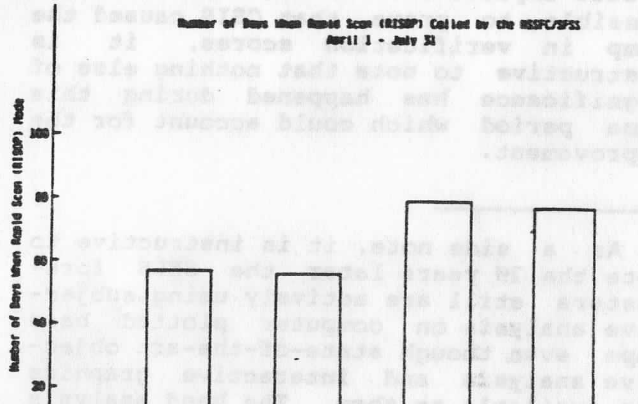

Figure 2. The number of days when 15 minute rapid scan (RISOP) mode of operation for the GOES satellite was called by the NSSFC/SFSS. The timely display of satellite data on CSIS has resulted in the forecaster making more use of the rapid scan data.

each FA forecaster is able to do the work previously done by three forecasters without any significant decrease in the quality or quantity of the forecast products. It is worth noting that the FA unit still has many areas which could be improved with interactive technology. A major effort at the NSSFC has been targeted at improving the FA unit's efficiency by developing features in CSIS specifically oriented toward FA problems.

5. SUMMARY

The National Severe Storms Forecast Center (NSSFC) in Kansas City has the most modern interactive processing equipment of any operational forecast office in the United States. As such, the experiences of the NSSFC serve as an indication of some of the benefits which will be derived from interactive technology when it is applied in other forecast situations. The NSSFC consists of five forecast units. The current interactive computer capabilities have been assembled over a number of years through a variety of projects and funding sources. There has been no master plan guiding the development, funding, or procurement of equipment. Consequently, the current systems are fragmented and are in need of consolidation, which should be accomplished as part of the National Centers Upgrade during the late 1980s. However, when the current hardware capabilities are taken as a sum total, they closely approximate the type of system being considered for operational meteorological offices during the coming decade.

The impacts of the interactive technology are many and varied. Message composition has been greatly afffected by the interactive technology. Word processing equipment is critical to many of the units operations. The current NSSFC forecast missions simply would not be possible without good word processing equipment. Computer aided message composition has been used very efficiently by the SELS unit to cut the time required to issue a severe storm or tornado watch from 25 minutes to five minutes. Interactive graphic techniques have been used by SELS to interactively outline watch areas. The computer provides the geographic and city name information needed for the message. Current plans call for expanding these interactive graphic message composition techniques to other message types such as boundaries defined by a series of cities.

The timely presentation of data available with the interactive image devices at the NSSFC has had several impacts. The number of mesoscale update satellite interpretation messages issued have more than doubled since the Centralized Storm Information System (CSIS) was installed in 1982. These short range forecasts are not only more frequently issued, but they have a higher information content. Another indication of the usefulness of timely satellite data has been the increase in the number of requests for rapid scan (15 minutes between images) data from the GOES satellite.

Another indication of the positive impact of interactive technology is the improvement in the verification scores of the SELS tornado watch forecasts. After the CSIS system was installed in 1982, there was a noticeable improvement in the verification scores.

Finally, the overall efficiency of the forecasters has been improved by the interactive technology. Many of the forecasters feel that the reduction in manual housekeeping functions allowed by the computers has resulted in more time for meteorological functions. A telling example of this is the centralized aviation area forecast (FA) unit at the NSSFC. Prior to 1982, this function was distributed among several offices. With the centralization came a three to one reduction in staff. There has been no major degradation in the quality or quantity of the forecast products. Modern interactive computer technology is one of the major reasons this was possible.

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