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Use of a Personal Computer Workstation for Short Range Forecasting: A Case Study

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1.0 Introduction

During the Spring of 1985, the first phase of a field experiment to study mesoscale convective weather over the central plains of the United States was conducted. The project, known as the PRE-STORM Program, was based at Will Rogers Airport in Oklahoma City, OK. Long term goals of this program include developing a deeper understanding of mesoscale convective systems (MCSs), and improving the forecast of MCS formation, location, duration and strength. The main objectives of the 1985 field project were (1) to develop a reliable observing system for investigating MCSs, and (2) to initiate scientific investigations. It was in this environment that the National Environmental Satellite Data and Information Service (NESDIS) group at Colorado State University (CSU) chose to field test a new "workstation" configuration on a personal computer (PC). The workstation utilizes video-graphic capabilities to display satellite imagery and quantitative data which are accessed from a central computer (in this case from the University of Wisconsin McIDAS (Soumi, et al, 1983) system). Products included real-time loops of both visible (VIS) and infrared (IR) imagery, plotted GOES satellite sounding (VAS) retrievals, and plotted and analyzed fields of several derived meteorological parameters.

The primary objective of the PC experiment was to evaluate the feasibility and utility of using a PC as an operational meteorological workstation. There are several advantages to such a concept. Hardware consists of relatively inexpensive, off-the-shelf components to which custom designed software may be written to provide a productive tool for the forecaster. The environmental and electrical requirements are minimal; an important consideration for field experiments. Because of the low cost, a PC could supplement conventionally available data with special data sets. Specific features evaluated were 1) reliability of the hardware and communications, 2) usefulness of lower resolution displays, and 3) speed of data processing.

Another prime objective of the study was to assess the usefulness of VAS retrieval information in forecasting MCSs. Given the presence of the general synoptic ingredients associated with MCS development, the forecaster requires tools to monitor convection developing on scales not readily observed by other methods (e.g. radar). Conventional VIS and IR satellite data are ideal for this task, particularly when sequential imagery is available in animated form. An even greater advantage would be a data source which would allow the forecaster to monitor the mesoscale airmass evolution throughout the day. It is hoped that VAS retrieval information will fill a large part of this need. To this end, various VAS retrieval products were evaluated as to their effectiveness in real-time forecast operations during PRE-STORM.

2.0 Personal Computer Workstation

A microcomputer-based meteorological research workstation has been in development over the past two years through a joint effort among the NOAA/NESDIS Development Laboratory, Space Science and Engineering Center at University of Wisconsin and the Cooperative Institute for Research in the Atmosphere at Colorado State University (Dedecker, et al, 1985). The hardware components are based on the IBM series of personal computers with peripherals of various manufacturers.

The base processor is an IBM PC/XT with a ten megabyte hard disk, 640K bytes of memory and a numeric processor to increase floating-point calculations speed. Two video monitor displays are used: 1) a monochrome screen which provides the text display for menus and alpha-numeric data, and 2) a color screen for graphical displays and imagery presentations. A dot matrix printer provides the capability of hardcopy of products displayed on either screen. Data transfer from the mainframe computer utilizes a 1200 baud automatic-dial modem connected to a standard telephone line.

Although unmodified hardware is used in the workstation, several additional resident system assembly language routines were written to supplement the standard PC operating system. New features include control for twin display monitors, parameter storage for passing information among different applications programs, and provisions for animation of satellite image graphics. Three different color graphic resolutions are available in the workstation for data display: 1) low resolution -- 100 rows of 160 elements with 16 colors displayable; 2) medium resolution -- 200 rows of 320 elements with 4 colors displayable; 3) high resolution -- 200 rows of 640 elements with a pixel either on or off. Up to 24 of these graphics may be stored in system memory to provide for animation with user definable looping rates up to 15 frames per second.

The applications programs for communications, image display, and VAS retrieval processing were written in Pascal and FORTRAN for efficient data processing. A menu driven system was chosen as the user interface so as to minimize keyboard input. Program selection is by function keys, data file selection is by number in a list, and program control is by single letter commands. Access to the mainframe data base features automatic dial, logon, data transfer and logoff to further lessen the need of the user to be knowledgeable of computer details.

Realtime satellite data were required to support the PRE-STORM Operations Center during mission flight days. A scheduler program was written to read a list of products and associated acquisition times and automatically transfer these from the mainframe database. This unattended product transfer allowed the meteorologist to provide forecasting support and handle other duties and yet be assured that the most current data would readily be available.

Because the standard personal computer is a single-user, single-task processor, two PC's were used at PRE-STORM. Both had identical hardware and software, but at power-up each day the meteorologist could choose one to be the dedicated automatic scheduler and the other to be the interactive workstation. The scheduler system allowed the workstation to be used for forecasting and analysis support nearly full time. As new products were acquired, the data were transferred between systems with floppy diskettes. The two computer arrangement also provided another operational requisite - redundancy. The product access and file update software was designed to optimally work in a two-computer mode; however, all data products may be manually acquired and all workstation analysis tools maintained in a one-computer system configuration. Operational support could be continued even with one system failure.

Image animation is an important tool for a satellite meteorologist. The workstation software was designed to loop the six most current images of visible, infrared and water vapor data. Since all 18 images are stored in memory, one can instantly switch among the three types of loops by pressing one key. Each loop could be customized as to looping rate and beginning and ending dwell and to eliminate a frame that may be incorrect.

3.0 The 6 May 1985 Case Study

The case chosen to illustrate the attributes of the workstation was typical of the PRE-STORM cases. A descriptive "replay" of this case follows, and shows how the combined satellite data can supply uniquely useful forecast input.

Analysis of the morning synoptic data indicated that conditions were favorable for MCS development. Winds aloft in Kansas (KS) and Oklahoma (OK) were from the west through southwest (20-30 kt at 500 mb; 10-15 kt at 700 mb). At low levels a weak stationary front trailed across northwest OK on a line from southeastern New Mexico to eastern KS. Moderately strong, low level southerly flow was developing over most of TX and OK. Numerical guidance expected the front to drift north during the day, and a weak shortwave to arrive in the area by late afternoon.

The 1700 GMT data continued to show MCS potential, and satellite data helped appreciably in this diagnosis. The front had shifted a bit north, to a south-east KS/western TX panhandle line. Winds to the north of the front were upsloping into southeast Colorado (CO). VAS data collected at 1718 GMT (Fig. 1), found relatively low convective temperatures in the southeast CO region. Several surface sites were already within

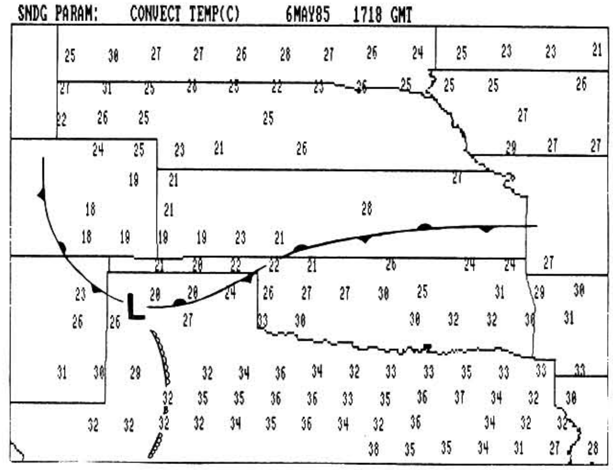

Figure 1. Convective temperatures as computed from 1718 GMT VAS retrieval data. Front and dryline locations from analysis of conventional data.

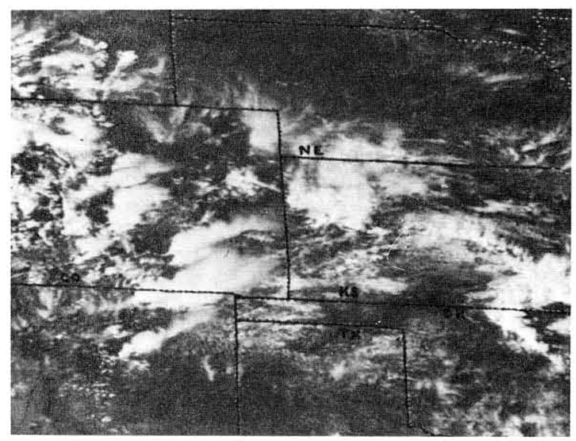

Figure 2. VIS satellite image from 2031 GMT 6 May 1985.

1°C of reaching their critical value, and 1800 GMT VIS imagery (not shown) found deep convection developing in that area. Instabilities computed from VAS soundings showed moderate thunderstorm potential in southeast CO which became increasingly strong toward the southeast.

The real-time utility of the retrieval data was somewhat diminished by data processing requirements. By the time the VAS information had been processed and was available to the forecaster on the workstation, conventional VIS imagery had already revealed convection in progress. For this forecast period, the time required for data processing used up the lead-time which the VAS soundings had had the potential of delivering for the CO convection. On the other hand, the information regarding convective potential to the southeast provided support for the short range forecast of continued development.

Early afternoon VIS and IR loops showed a strengthening of the convection in southeast CO (Fig. 2), and new development along the front in northern OK. This corresponded with the region along and near the front where the lifted parcel buoyancy was increasing (Fig. 3), and low-level negative buoyancy (i.e., the capping inversion) was decreasing (Fig. 4). At this time, the VAS

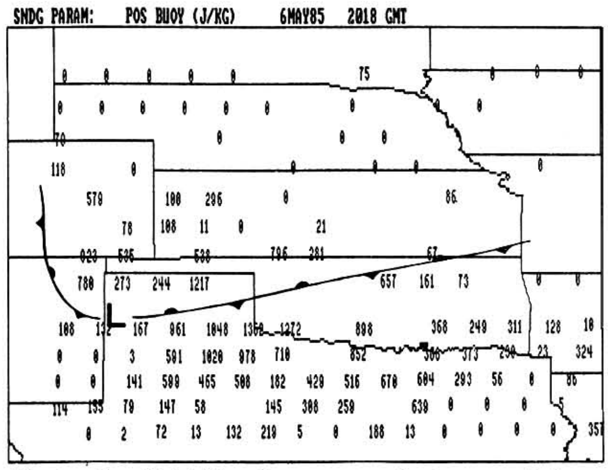

Figure 3. Positive buoyancy values computed from 2018 GMT VAS retrieval data. LCL computed from the lowest kilometer mixed temperature/ dewpoint. Frontal position from conventional data.

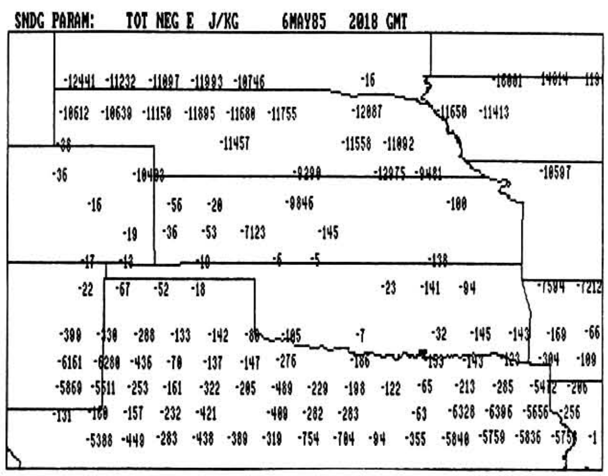

Figure 4. Negative buoyancy values computed from 2018 GMT VAS retreival data. LCL as in fig. 3.

information represented more than confirmation. Rather, it showed a significant broadening of both the areas of high positive buoyancy and low negative buoyancy (comparative figures not shown). The knowledge that a large portion of the area of interest has a very unstable, decreasingly capped airmass is important input to a short range forecast concerned with MCS development.

By late afternoon all indications were that the threat area for MCS formation would be the western two-thirds of OK. Precipitable water values were fairly high (3.5 - 4.0 cm) in that region. That factor, combined with the diurnal heating which had occurred, resulted in a continued increase in positive buoyancy (Fig. 5), and further erosion of the cap (Fig. 6). Furthermore, the evening synoptic run revealed a strong 850 mb moist jet coming up from the Gulf, and a shortwave trough entering the state from the west as had been expected. It was evident that convection in progress in the OK panhandle and extreme northwest OK would continue to expand well into the evening, as verified by Figure 7.

The convection had, by 0600 GMT, become a fully mature MCS which continued to move slowly

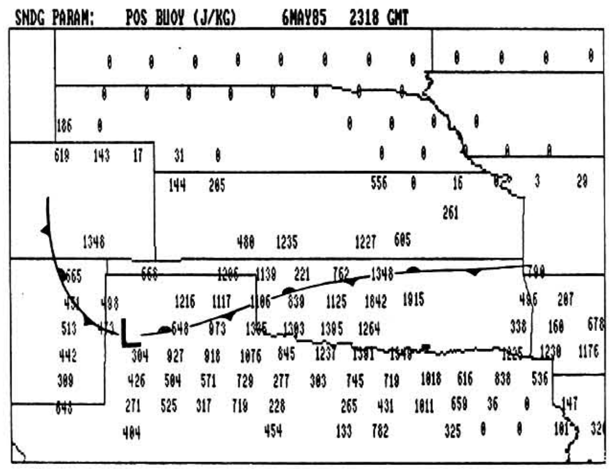

Figure 5. Same as figure 3 except for 2318 GMT retrieval data.

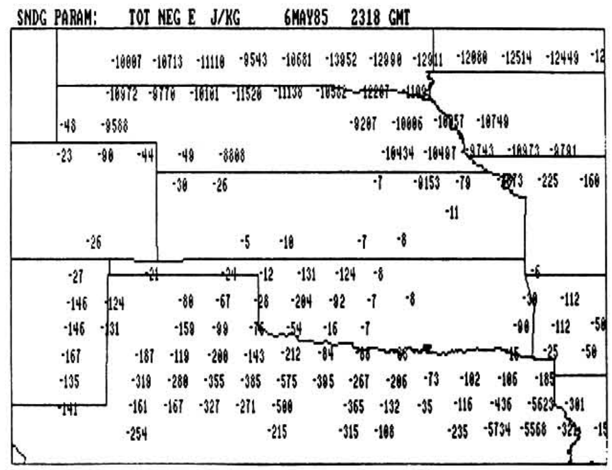

Figure 6. Same as figure 4 except for 2318 GMT retrieval data.

eastward until roughly 1200 GMT when it entered eastern OK and dissipated. It had been a "typical" MCS in most aspects, and been fully predictable in the short range using a combination of satellite data (collected and processed at the PC workstation), and conventional data (available through NWS AFOS). Whether or not the VAS data will prove consistently useful will require further study.

4.0 Concluding Remarks

During the PRE-STORM experiment, the PC hardware functioned with exceptional reliability. Many features of very expensive image and graphic display systems (e.g., McIDAS, PROFS, CSU's IRIS) proved to have been successfully incorporated into an inexpensive workstation. Compromises were made as to the display resolution and data processing speed, but no special electrical power, air conditioning or communications lines were needed. A mainframe computer was required to be the database generator and file server.

It is clear that digital images can be delivered and displayed on a PC workstation several minutes faster than through the more conventional GOES-tap process. However, use of the lower resolution, visible imagery products in real-time made it evident that higher resolution display hardware is necessary for forecast

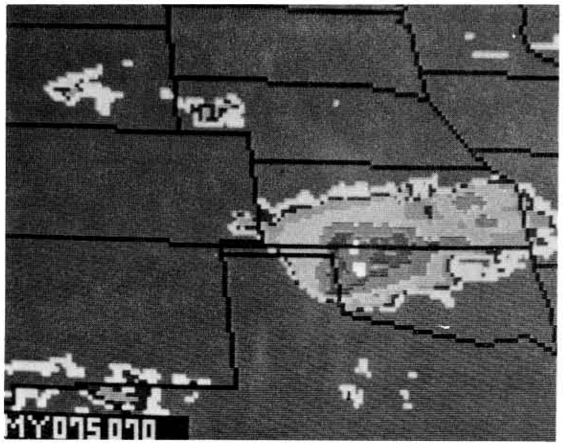

Figure 7. GOES-West, IR satellite photo from 0700 GMT on 7 May 1985 showing developing MCC over the eastern TX panhandle and western OK.

application.

Image products were capable of being ready for transfer to the PC at ten minutes after image time. However, the mainframe computer is a research-oriented system which does not have operational, product scheduling capabilities. As a result, some image updates were as much as two hours late during the peak usage hours of the day. The transfer time of image products to the PC varied from two to four minutes for halftone visible products to one to two minutes for IR and water vapor images with variations due to the amount of cloud cover in the images.

VAS retrieval production had a normal processing time of two to two and a half hours after data time on the mainframe. This period included data ingest, numerical processing, manual editing and PC-compatible formatting. As with image processing, the timing could be longer based on the actual system load. For the PRE-STORM area, a maximum number of retrievals for one time period was 190, which required about 12 minutes of telephone transfer time plus another 25 minutes of data processing to complete the PC workstation retrieval data base. The time delay from data time to availability to the meteorologist was at best three to three and a half hours.

At the time of this writing, only a few real-time forecast events have been documented that use the combination of VISSR/VAS data as a major input. The experiment resulted in some very positive conclusions regarding the utility of VAS data in short range convective forecasting. In particular, many of the products derived from the retrieval data at the workstation resulted in important, and previously unobtainable, information as illustrated by the case study. A few of the more useful parameters included:

a) Convective temperature fields -- which, in combination with high temperature forecasts, show regions likely to develop convection later,
b) Positive buoyancy from the convective cloud base level -- which quantifies the expected strength of the convection in areas where it is expected to develop (from "a" above),
c) Positive buoyancy from the LCL -- for use later in the day when substantial heating has occurred,
d) Negative buoyancy -- which supplies information about the low-level cap,
e) 850 mb temperature -- for low-level warm air advection, and
f) Total precipitable water.

Various combinations of these few parameters identified the increasing convective potential on the afternoon and evening of 6 May, while at the same time many local forecasters (using conventional data alone) actually reduced thunderstorm probabilities in the evening forecast update. On several occasions during the PRE-STORM experiment, the VAS fields seemed to represent a realistic mesoscale overview of the developing situation. At other times, however, there were a few false indications of convective potential. These instances will need to be studied to diagnose what occurred to cause the false alarm. Research will continue in the use of VAS retrieval parameters for mesoscale forecasting.

4.2 Acknowledgements

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5.0 References

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