

Application of the 4-D McIDAS to a Model Diagnostic Study of the Presidents' Day Cyclone

W. Hibbard,*
L. Uccellini,**
D. Santek,*
and K. Brill⁺

Abstract

The four-dimensional (4-D) McIDAS system is applied to a numerical simulation of the rapid development phase of the Presidents' Day cyclone. Selected frames from a videotape of the model simulation are presented to illustrate the evolution of the upper- and lower-tropospheric potential vorticity maxima prior to and during rapid cyclogenesis. The 4-D structure of various airstreams converging toward the cyclone center are also displayed. Our experience with 4-D displays of model output indicates that these systems offer a tremendous opportunity to manage and dissect the information content inherent in numerical simulations. The production of the visualizations of the Presidents' Day cyclone also confirmed a need for an interactive system capable of producing various perspectives in real time, a requirement being addressed with the development of a new workstation at the University of Wisconsin Space Science and Engineering Center.

1. Introduction

The application of high-resolution numerical model output to case studies of severe weather events provides the opportunity to study atmospheric circulation systems with a confidence level not previously attained using the operational data network alone; an advancement that is having a significant impact on synoptic meteorology (Keyser and Uccellini 1987). Whitaker et al. (1988) present a synoptic analysis and diagnostic study of the 19 February 1979 Presidents' Day cyclone using a regional-scale numerical-model simulation in which the details of their analysis far exceed previous analyses based only on 12-h operational radiosonde data (Bosart and Lin 1984; Uccellini et al. 1985). Model datasets at 15-min to 1-h intervals were used to study various physical processes, including jet streak circulation patterns, a stratospheric extrusion within a tropopause fold, la-

tent heat release, and sensible heat fluxes within the planetary boundary layer that were all related to the rapid cyclogenesis that marked that case. More importantly, the use of high-resolution model data by Whitaker et al. provides the means to resolve the interaction of the various physical processes, trace the stratospheric and lower tropospheric potential vorticity maxima, and compute detailed trajectories depicting the three-dimensional (3-D) airflow through the developing storm system.

The major problem that now confronts the meteorologist attempting to dissect model simulations of scale-interactive weather and climate processes is not a lack of useful and dynamically consistent datasets, but the real possibility of being overwhelmed by the model data. This is especially true when a short time interval in the model output is required to resolve the processes that interact to produce the rapid evolution of severe weather events. The purpose of this paper is to describe an application of the Man Computer Interactive Data Access System (McIDAS) at the University of Wisconsin's Space Science and Engineering Center (SSEC) to produce a four-dimensional (4-D) display of selected meteorological fields generated by the model simulation of the Presidents' Day cyclone.

The 4-D McIDAS system (Hibbard 1986a) is designed to manage and analyze very large datasets (either from remote sensing instruments or numerical models) and to produce complex, 3-D multivariate images from these datasets. The real power of the system involves the animation of these fields and the ability to change the perspective so that meteorologists are provided the means to "observe" the atmosphere in motion from various points of view. Sequences of the model fields and trajectories have been animated for the Presidents' Day cyclone and recorded on videotape. We can, of course, only provide snapshots of selected model-generated fields and trajectories in this paper to highlight the type of imagery and the range of perspectives available.

A brief review of the 4-D McIDAS system is provided in section 2, and the steps taken to apply this system to the Presidents' Day storm simulation are discussed in section 3. Selected examples of meteorological fields are displayed in section 4 and the results and future plans are summarized in section 5.

* Space Science and Engineering Center, University of Wisconsin—Madison, Madison, WI 53706

** Meteorological Operations Divisions, National Meteorological Center, Camp Springs, MD 20746

⁺ General Sciences Corporation, Code 612, NASA/GSFC, Greenbelt, MD 20771

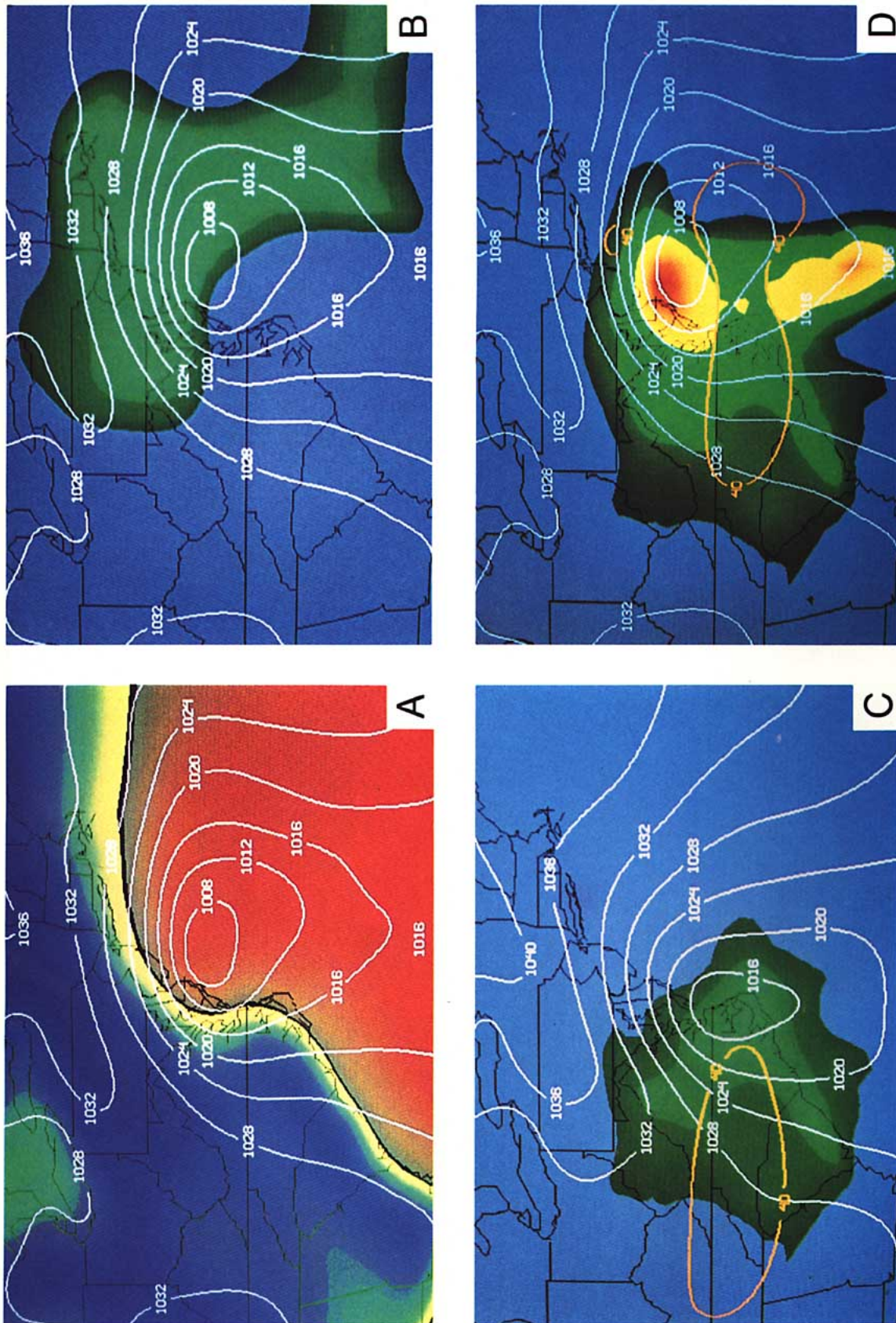
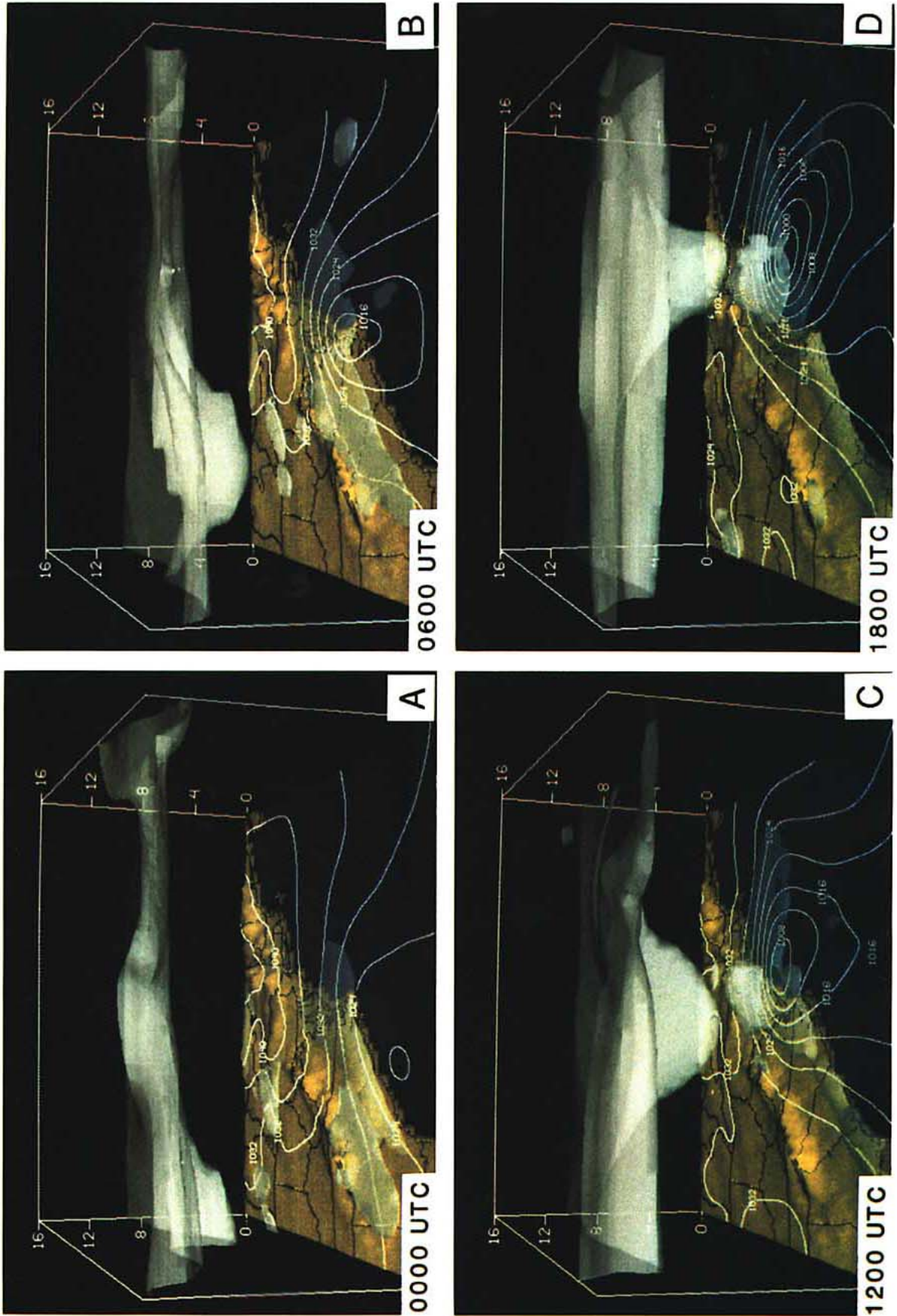


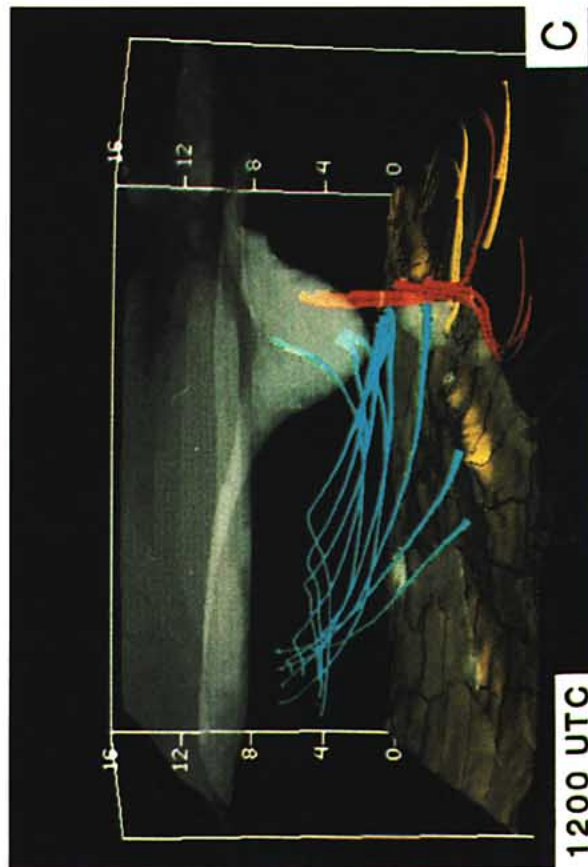
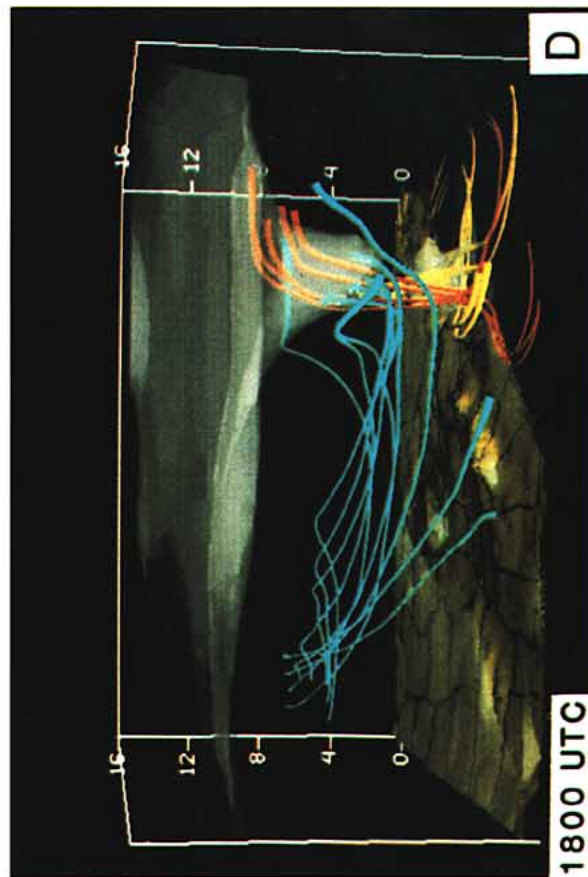
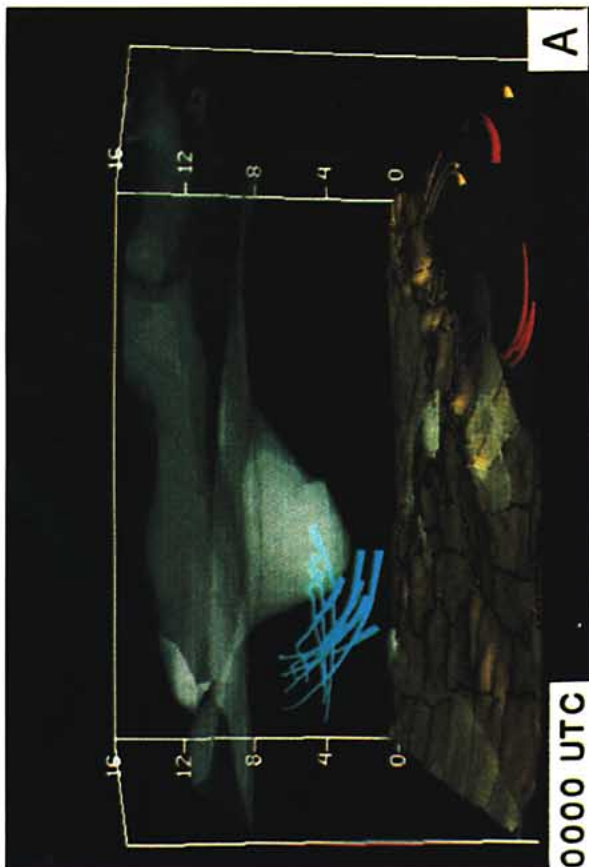
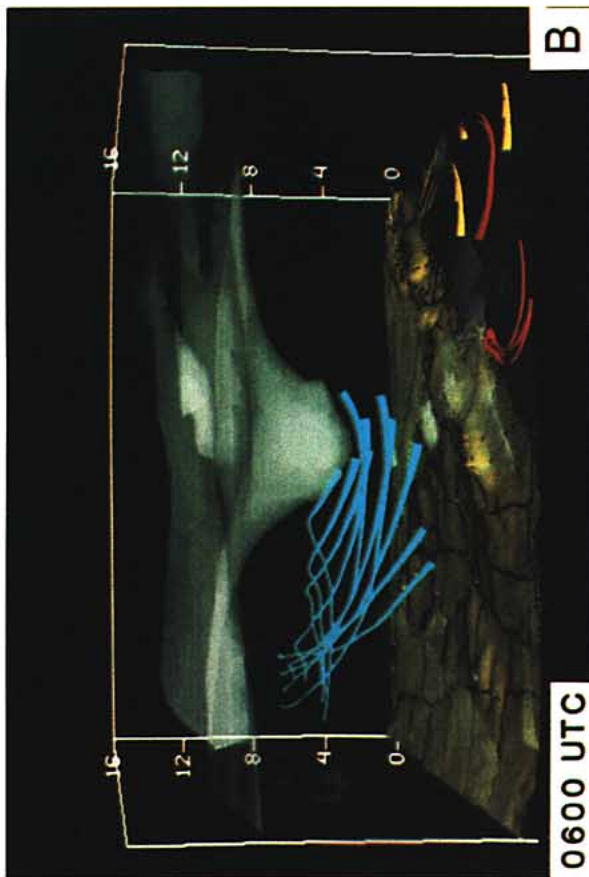
FIG. 1. Two-dimensional (2-D) displays of model-generated fields of the Presidents' Day cyclone (a) sea level pressure at 1200 UTC 19 February (mb), and temperature on lowest model sigma surface; shaded interval for isotherm analysis is 1°C with the 0°C line indicated in black; (b) sea level pressure (SLP) and relative humidity at 700-mb level at 1200 UTC 19 February; light green is 70% and dark green is 90% relative humidity; (c) SLP, 40 m s⁻¹ isotach at 500 mb level, and accumulated precipitation shown for 0600 UTC 19 February and (d) 1200 UTC 19 February; color interval for accumulated precipitation is 1 cm, 2 cm and >4 cm.

FIG. 2. Three-dimensional (3-D) perspectives (as viewed from the south) of the $2 \times 10^{-5} \text{ K mb}^{-1} \text{ s}^{-1}$, potential vorticity surface, and SLP pattern (mb) derived from the numerical simulation of the Presidents' Day cyclone (Whitaker et al. 1988) for (a) 0000 UTC, (b) 0600 UTC, (c) 1200 UTC, and (d) 1800 UTC 19 February 1979.

3D PERSPECTIVE OF THE PRESIDENTS' DAY STORM: 19 FEBRUARY 1979



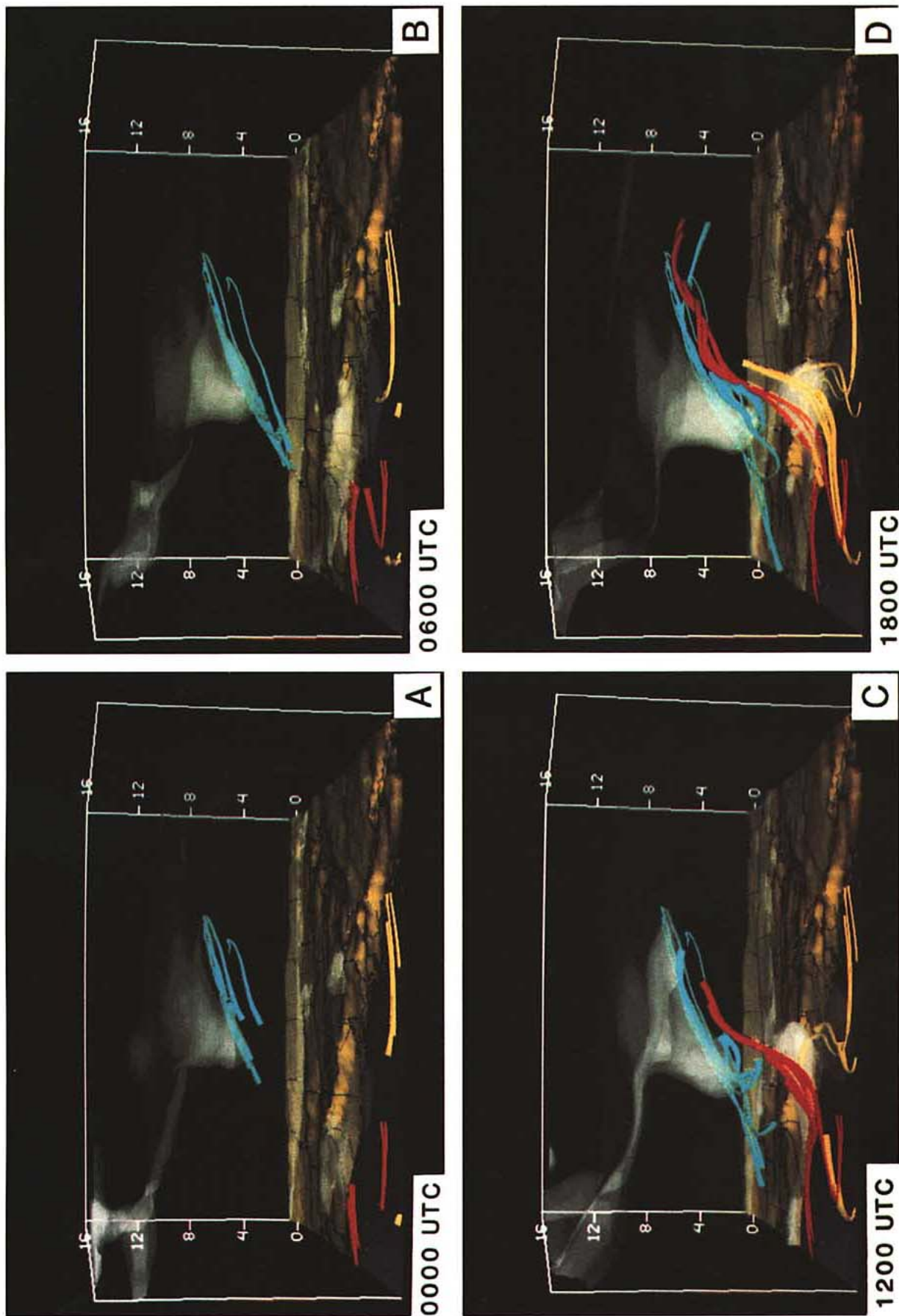
**AN OBSCURATIVE OF THE PRECIPITATION, RAY STORM. 10 FEBRUARY 1070
3D PERSPECTIVE OF THE PRESIDENTS' DAY STORM: 19 FEBRUARY 1979**



WILLIAMS ET AL. (1970). BLUE TRAJECTORIES ORIGINATE WITHIN STRATOSPHERIC EXTRUSION WEST AND NORTH OF THE CYCLONE, AND YELLOW AND RED TRAJECTORIES ORIGINATE IN THE LOW LEVELS WITHIN THE OCEAN-INFLUENCED PLANETARY BOUNDARY LAYER EAST AND SOUTH OF THE CYCLONE.

FIG. 4. As in figure 3, but as viewed from an eastern perspective, illustrating the sloped nature of both the potential vorticity surface and the ascent of the trajectories approaching the storm system from the south.

3D PERSPECTIVE OF THE PRESIDENTS' DAY STORM: 19 FEBRUARY 1979



2. The four-dimensional McIDAS

The 4-D McIDAS is a set of software integrated within the McIDAS system, a development guided by its application to a variety of datasets including numerical model output (Santek et al. 1987; Pauley et al. 1988; Meyer and Seablom 1988) and remote sensing observations (Hibbard 1986a; Hibbard 1986b). The 4-D McIDAS provides tools to manage data as 2- and 3-D grids, as trajectories, as images, and as collections of data without any spatial order. The grid structures can be grouped to manage very large datasets spanning multiple physical variables and sequences of times. These 4-D McIDAS data-management tools include file structures for storing data, libraries of routines for accessing those files, user commands for housekeeping functions (listing, copying, etc.) on those files, and programs for converting external data to those file formats.

The 4-D McIDAS includes a variety of commands for analyzing data in the McIDAS file structures. These include

- 1) resampling grids to a different spatial resolution, map projection, or vertical coordinate
- 2) resampling time sequences of grids to a different temporal resolution
- 3) transforming grids to a moving frame of reference
- 4) generating general arithmetic grid operators
- 5) interpolating nonuniform data to a grid
- 6) deriving trajectories from grids of wind components
- 7) creating images from grids

The 4-D McIDAS is used to produce animated sequences of 3-D images from data in the McIDAS file structures. The visual elements of these images include

- 1) shaded relief topographical maps with physical and political boundaries
- 2) trajectories drawn as shaded tubes, which may be either opaque or semitransparent, and may be long and tapered or short with the length made proportional to wind speed
- 3) isolevel contour surfaces of 3-D scalar variables, which may appear smooth with natural shading, may be semitransparent, or may have a gridded "fishnet" appearance. (An example would be a surface of constant wind speed enclosing a jet stream.)
- 4) isolevel contour lines, drawn either on the topographical surface or on a surface in the atmosphere (such as an isobaric or theta surface)
- 5) images projected onto 2-D surfaces in the atmosphere, such as those scanned by radar or

lidar

- 6) 3-D translucent volumes with opacity proportional to some scalar physical variable. (This is a natural way to depict cloud water density.)
- 7) cloud top surfaces generated from visible and infrared satellite images

These 3-D images are assembled into animated sequences showing the time evolution of a dataset, or showing a rotating view of a single time within a dataset. The animated sequences are loaded into the McIDAS workstation where they can be viewed directly or recorded onto videotape.

The 4-D McIDAS provides a variety of means to increase viewer comprehension of the images it produces. The images are generated in color, and the user can control the color of each physical variable. The user can also control the scale of the depicted spatial region and the rotation of the user's viewpoint. Depth information is somewhat ambiguous in 3-D images, and a rotating perspective helps resolve this ambiguity. However, the apparent motions of depicted objects become ambiguous when rotation is simultaneous with time animation. Our solution to this problem is to apply a slight "rocking" to the entire 3-D domain during time animation. The rocking is not ambiguous with most meteorological motions, and it does enhance the sensation of depth.

We have used the 4-D McIDAS system to produce videotapes from many datasets. These videotapes are generally composed of many separate animation sequences, including 2- and 3-D images. The different animation sequences show the data at a variety of scales and viewpoints, and with different combinations of physical variables. Given the complexity of a large dataset, and the large amounts of human and computer resources needed to create a videotape, we have found it important to work from a script. The script provides a way to plan the presentation, to see its parts in perspective, and to avoid making costly mistakes during the repetitive parts of the production process.

3. McIDAS applied to the Presidents' Day storm

The rapid development phase of the Presidents' Day storm was simulated at the Goddard Space Flight Center (GSFC) using the Mesoscale Analysis and Simulation System (MASS) as described by Whitaker et al. (1988). The dataset consists of 2- and 3-D grids plus trajectories computed at 15-min intervals over a 36-h period from 1200 UTC 18 February to 0000 UTC 20 February 1979. Three-dimensional grids for temperature, specific humidity, u and v wind com-

ponents, and potential vorticity include data for all 32 levels of the model. There are 2-D grids for terrain topography, surface pressure and pressure tendency, surface temperature, stable and convective precipitation, and planetary boundary-layer thickness. The 2- and 3-D grids are in a polar stereographic projection of 102×70 grid points. The dataset also includes 21 selected trajectories computed at GSFC using an iterative technique and a 15-min model output as described by Whitaker et al. (1988).

For the purpose of visualizing the storm's development, we used the 4-D McIDAS tools to select a subset of this dataset, covering 60 time periods, at half-hour intervals between 1500 UTC 18 February and 2030 UTC 19 February 1979. The gridded data were interpolated to pseudocylindrical projections (constant latitude and longitude grid intervals) covering several geographical subsets of the original region and to uniform height levels in the vertical.

The goals of this effort are to visualize the basic evolution of the sea level pressure (SLP) field, the relationship of this development to upper-level jets and convergence of various airstreams during the storm development, the cold air damming along the coast, and the relation of potential vorticity to the converging airstreams and rapid cyclogenesis. Satisfying our goals required many trial and error adjustments to

- 1) the map scale
- 2) the view angle
- 3) the combination of physical variables
- 4) the contour levels of scalar variables
- 5) the color and transparency of various image elements
- 6) the means of displaying trajectories

This trial and error process was very time consuming, usually requiring several hours to see the result of even a small change. This effort illustrates the need for a more interactive system.

4. Examples of colored displays of the Presidents' Day cyclone

In this section, several examples of the 2- and 3-D colored displays are presented to illustrate the ability of the system to overlay various fields and provide insight into the structure of and airflow through the rapidly developing cyclone. These examples, of course, cannot convey the true power of the system, which can only be appreciated when viewing the videotape sequences.

a. 2-D displays

The SLP pattern and analysis of the temperature on the lowest model surface (approximately 20 mb above the ground) are shown in figure 1a and depict the position of the developing surface low-pressure system with respect to the enhanced baroclinic region along the East Coast of the United States at 1200 UTC 19 February. The model simulation captures the damming of the colder air (less than 0°C in blue) between the Appalachian Mountain range and the coastline and the warmer air (15° – 20°C) immediately off the coast. The combination of the 700 mb relative humidity and SLP (figure 1b) shows that the surface low also developed along the gradient between the moist rising air to the north and east of the storm center and dry subsiding air to the south and west. The development of the surface low along this relative humidity gradient is indicative of the asymmetric cloud structure that marks extratropical cyclones—a direct result of the convergence of various and distinctly different airstreams toward the storm center.

The sequence of SLP, accumulated precipitation, and the 40 m s^{-1} isotach at the 500 mb level (figures 1c and 1d) illustrates the rapid development of the simulated cyclone between 0600 UT and 1200 UTC 19 February. The colorized sequence provides supporting evidence that rapid cyclogenesis commenced as the exit region of the upper-level polar jet streak approached the East Coast, and as the precipitation rate increased to the north of the surface low within the cyclonic side of the jet exit region. Combining these model fields within a time sequence provides supporting evidence for the importance of both the dynamic and thermodynamic processes (i.e., jet streak circulation patterns and latent heat release) and their interaction as important factors for the onset and maintenance of rapid cyclogenesis.

b. 3-D displays

Attempts have been made to link the extrusion of stratospheric air into the upper- and middle-troposphere to cyclogenesis through the principle of conservation of isentropic potential vorticity (IPV), where $\text{IPV} \equiv (\zeta_0 + f)\partial\theta/\partial p$. As stratospheric air descends into the troposphere, the air mass is stretched and the static stability ($-\partial\theta/\partial p$) decreases significantly. Consequently, the absolute vorticity ($\zeta_0 + f$) increases with respect to parcel trajectories as long as the stratospheric values of IPV are preserved. Recent review articles by Hoskins et al. (1985) and Uccellini (1989) emphasize the impact of the IPV anomalies on surface cyclogenesis. Through an "invertibility principle" expressed by Kleinschmidt (1950), Hoskins et al. show that a positive IPV anomaly that extends

downward from the stratosphere into the middle troposphere provides an optimal situation for enhancing the IPV advection in the middle and upper troposphere which acts to induce a cyclonic circulation that extends throughout the entire troposphere. The downward extrusion of stratospheric air from the normal tropopause level to the middle and lower troposphere is known to occur in narrow zones along upper-level front/jet streak systems, a process called tropopause folding (Reed 1955; Reed and Danielsen 1959; Danielsen 1968).

As noted by Uccellini et al. (1985), the dominant theme has been to relate the *simultaneous development* of the tropopause fold to cyclogenesis. However, a result of the Uccellini et al. and Whitaker et al. (1988) studies of the Presidents' Day cyclone is the emphasis on the probable link between upper-level frontogenesis and tropopause folding associated with jet streak transverse circulation patterns and the *subsequent* development of surface cyclones. To show the tropopause fold prior to cyclogenesis, the subsequent translation of the stratospheric air eastward toward the East Coast, and the interaction of this air mass with a low-level IPV maximum, Whitaker et al. (1988) utilize numerous standard four-panel horizontal and cross-sectional figures in their paper. The application of the 4-D McIDAS provides a clear depiction of these features, as illustrated below.

The 3-D perspective of the simulated tropopause fold and eastward displacement of the stratospheric air mass is shown from a southern perspective in figure 2, with selected trajectories in figure 3, and from an eastern perspective in figure 4, at 6-h intervals between 0000 and 1800 UTC 19 February. The descent of the $2 \times 10^{-5} \text{ K mb}^{-1} \text{ s}^{-1}$ IPV surface within a tropopause fold and advection of this IPV anomaly toward the East Coast and subsequent deepening of the surface cyclone are clearly depicted in the 3-D illustrations. Figure 2 depicts the descent of the stratospheric air mass down to the 700-mb level 12 h prior to and 1500 km upstream of the developing cyclone in association with a descending airstream (blue trajectories in figures 3 and 4) originating on the cyclonic side of the polar jet streak (depicted in figures 1c and 1d). Whitaker et al. (1988) show that this stratospheric extrusion was related to subsynoptic scale processes associated with the upper-level jet/front system in the middle of the United States. The eastern perspective (figure 4) is included to show the tilt of the tropopause fold (represented by the IPV surface) toward the south as the stratospheric air descends beneath the jet core and moves toward the east, with the expected general tropopause slope (higher to the south and lower to the north) also depicted. The model-generated images of the tropo-

pause fold are similar to the schematics produced by Danielsen (1968).

The model-simulated IPV fields in figures 2–4 also display a separate region of high IPV confined to the lower troposphere along the East Coast that extends upward during the period of rapid cyclogenesis. As discussed by Gyakum (1983), Bosart and Lin (1984), Boyle and Bosart (1986), and Whitaker et al. (1988), diabatic processes (primarily associated with the vertical and horizontal distribution of latent heat release within a low-level baroclinic zone) contribute to the development of the low-level IPV anomaly. The low-level IPV maximum will also induce a cyclonic circulation extending upward throughout the entire troposphere and add to the circulation induced by the upper-level system, as long as the low-level IPV maximum remains downwind of the upper-level maximum, maintaining a positive feedback between the two. As with the upper-tropospheric IPV surface, rotating the display from a southern perspective (figure 3) to an eastern perspective (figure 4) provides an indication of the sloped nature of the low-level inflow and IPV surface (from south to north) as the separate IPV maxima begin to merge by 1800 UTC (figure 4d).

The previous discussion of the cyclogenetic processes as viewed from an IPV perspective provides a basis for linking upper- and lower-tropospheric processes in the evolution of a rapidly developing storm. This perspective is similar to the "type B" cyclogenesis described by Petterssen and Smebye (1971), which relates the advection of absolute vorticity ahead of an upper-level trough over a thermal advection pattern associated with a low-level baroclinic zone to surface cyclogenesis. Both perspectives not only account for the upper-tropospheric processes associated with trough/ridge systems and jet streaks, but also for the influence of low-level baroclinic zones in the evolution of these storms. The depiction of model results on the 4-D McIDAS clearly show that both of these perspectives are applicable to the Presidents' Day cyclone.

Finally, the trajectories shown in figures 3 and 4 give the appearance of distinct airstreams and "conveyor belts" as described for extratropical storms by Browning and Harrold (1969) and Carlson (1980). The "dry airstream" (represented by the blue trajectories) descending from the west-southwest, a "cold conveyor belt" (represented by the red trajectories) originating off the northeast coast of the United States and approaching the cyclone from the east, and a "warm conveyor belt" approaching the storm from the south and rising rapidly in a sloped-narrow band and turning anticyclonically are all depicted by the 4-D McIDAS display in figures 3 and 4. The low-level trajectories in figures 3 and 4 that 1) approach

the storm from the east and wrap around the center, and 2) approach the storm center from the south and rise rapidly in a narrow-sloping band before turning anticyclonically pass through the low-level 2×10^{-5} K $\text{mb}^{-1}\text{s}^{-1}$ IPV surface along the East Coast. These parcel trajectories are influenced by the latent heat simulated by the model and illustrate the nonconservative aspects of the low-level flow through the IPV maximum in a region of heavy precipitation (figures 1c and d; see Whitaker et al. [1988]).

5. Summary

Examples of 2-D and 3-D illustrations of selected fields from a videotape of a model simulation of the 19 February 1979 Presidents' Day cyclone demonstrate the value of 4-D display systems for visualizing voluminous datasets produced by numerical simulations of synoptic-scale phenomena. The application of the 4-D McIDAS system shows the interaction among various processes throughout the troposphere and lower stratosphere associated with two distinct potential vorticity maxima which are difficult to visualize with standard 2-D graphics procedures. Furthermore, the system provides a clear depiction of the 3-D structure of the various airstreams or "conveyor belts" that converge toward the cyclone center and extend from the planetary boundary layer to the tropopause. As noted earlier, the power of this approach can be realized by observing the time evolution of these diagnostic fields and trajectories, which are shown on the videotape. Versions of the videotape are available upon request.¹

The production of the videotape of the Presidents' Day cyclone was a slow and expensive process. The trial and error refinement of the animation of the Presidents' Day cyclone was inhibited by the long turnaround time of the system and the size of the dataset. What is needed is a system to provide a rapid visualization of the information inherent in numerical model output and remotely sensed observations. To meet these requirements, the McIDAS system has been recently converted to the Stellar GS-1000, a graphics supercomputer, and the 4-D McIDAS has been adapted to create 3-D animations *in real time* (the images are drawn at the animation rate). This system allows the user to explore a dataset of up to 50-million grid points, providing immediate visual feedback to the user's trial and error adjustments to the 3-D image animations (Hibbard and Santek 1989).

Acknowledgments. The authors would like to thank Dr. James Dodge of the National Aeronautics and Space Administration (NASA) for his encouragement and support of this effort. Funding for the University of Wisconsin 4-D McIDAS workstation was received from the NASA Marshall Space Flight Center (NAS8-36292).

References

- Bosart, L. F., and S. C. Lin. 1984. A diagnostic analysis of the Presidents' Day storm of February, 1979. *Mon. Wea. Rev.* **114**: 2432–2465.
- Boyle, J. S., and L. F. Bosart. 1986. Cyclone-anticyclone couplets over North America. Part II: Analysis of a major cyclone event over the eastern United States. *Mon. Wea. Rev.* **114**: 2432–2465.
- Browning, K. A., and T. W. Harrold. 1969. Air motion and precipitation growth in a wave depression. *Quart. J. Roy. Meteor. Soc.* **95**: 288–309.
- Carlson, T. N. 1980. Airflow through midlatitude cyclones and the comma cloud pattern. *Mon. Wea. Rev.* **108**: 1498–1509.
- Danielsen, E. F. 1968. Stratospheric-tropospheric exchange based upon radioactivity, ozone and potential vorticity. *J. Atmos. Sci.* **25**: 502–518.
- Gyakum, J. R. 1983. On the evolution of the QE II storm. II: Dynamic and thermodynamic structure. *Mon. Wea. Rev.* **111**: 1156–1173.
- Hibbard, W. 1986a. 4-D display of meteorological data. Proceedings, 1986 Workshop of Interactive 3-D Graphics. Chapel Hill, NC: SIGGRAPH. 23–36.
- Hibbard, W. 1986b. Computer generated imagery for 4-D meteorological data. *Bull. Amer. Meteor. Soc.* **67**: 1362–1369.
- Hibbard, W., and D. Santek. 1989. Visualizing large data sets in the earth sciences. *IEEE Computer*. **22**(8): 53–57.
- Hoskins, B. J., M. E. McIntyre and A. W. Robertson. 1985. On the use and significance of isentropic potential vorticity maps. *Quart. J. Roy. Meteor. Soc.* **111**: 877–946.
- Keyser, D., and L. W. Uccellini. 1987. Regional Models: Emerging research tools for synoptic meteorologists. *Bull. Amer. Meteor. Soc.* **68**: 306–320.
- Kleinschmidt, E., Jr. 1950. On the structure and origin of cyclones (Part 1). *Meteor. Rundsch.* **3**: 1–6.
- Kleinschmidt, E., Jr. 1957. Cyclones and anticyclones. In *Dynamic meteorology. Handbuch der Physik, Vol. 48*, ed. J. Bartels. New York: Springer-Verlag.
- Meyer, P. J., and M. S. Seabloom. 1988. Application of the four-dimensional McIDAS to LAMPS model output. Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Anaheim. AMS Preprint, pp. 33–36. Boston: American Meteorology Society.
- Pauley, P. M., W. Hibbard and D. Santek. 1988. The use of 4-D graphics in teaching synoptic meteorology. Conference Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology. Anaheim. AMS Preprint, pp. 37–40. Boston: American Meteorology Society.
- Pettersen, S., and S. J. Smebye. 1971. On the development of extratropical cyclones. *Quart. J. Roy. Meteor. Soc.* **97**: 457–482.
- Reed, R. J. 1955. A study of a characteristic type of upper-level frontogenesis. *J. Meteor.* **12**: 226–237.
- Reed, R. J., and E. F. Danielsen. 1959. Fronts in the vicinity of the tropopause. *Arch. Meteor. Geophys. Bioklim.*, **A11**: 1–17.
- Santek, D., L. Leslie, B. Goodman, G. Diak and G. Callan. 1987. 4-D techniques for evaluation of atmospheric model forecasts. Proceedings, Digital Image Processing and Visual Communications Technologies in Meteorology. Cambridge. SPIE. 75–77.

¹ Please contact William Hibbard at the Space Science and Engineering Center at the University of Wisconsin—Madison, Madison, WI 53706.

Uccellini, L. W. 1989. Process contributing to the rapid development of extratropical cyclones. Extratropical cyclones, Palmén Memorial Volume. Boston: American Meteorological Society (In Press).

Uccellini, L. W., D. Keyser, K. F. Brill and C. H. Wash. 1985. The Presidents' Day cyclone of 18–19 February 1979: Influence

of upstream trough amplification and associated tropopause folding on rapid cyclogenesis. *Mon. Wea. Rev.* **113**: 962–988.

Whitaker, J. S., Uccellini, L. W. and K. F. Brill. 1988. A model-based diagnostic study of the rapid development phase of the Presidents' Day cyclone. *Mon. Wea. Rev.* **116**: 2337–2365. ●

announcements

Solar 90 Conference

The Solar 90 Conference will be held 18–22 March 1990 in Austin, Texas. Solar 90 features the American Solar Energy Society Annual Conference and the 15th National Passive Solar Conference. For more information contact American Solar Energy Society, 2400 Central Avenue, Suite B-1, Boulder, Colorado, 80301, or call (303) 443–3130.

Canadian Society of Agrometeorology Technical Session

The Canadian Society of Agrometeorology (CSAM) is planning a one day technical session for 24 July 1990. The meeting will be part of the Agricultural Institute of Canada (AIC) 1990 Annual Conference to be held at the Convention Centre in Penticton, British Columbia. The theme of this conference is Agri-Resource interfaces. Participants are encouraged to share information and experiences, and are invited to attend the other A.I.C. sessions from 22–26 July. Poster presentations and equipment or instrumentation displays are invited. Please send a proposed paper title by 31 December 1989 and a 200 word abstract with the finalized title by 1 March 1990 to R.J. Williams, Agricultural Climatologist, B.C. Ministry of Environment, 1873 Spall Road, Kelowna, B.C. V1Y 4R2, or call (604) 861–7211.

ASTM Symposium on Mapping and Geographic Information Systems

The International Symposium on Mapping and Geographic Information Systems (GIS) will be held 21–22 June 1990 in San Francisco, California. Papers are invited for oral or poster presentations on three main topics: maps of all types—geologic, waste management, mineral, vegetation, land use, etc.; remote sensing—applications of all types and disciplines, hardware, and software (especially related to desk top computer applications); GIS—hardware and software, interface of maps and remote sensing with GIS, new applications, success and problems, and the need for data and other standards. Prospective authors should submit a 300–500 word abstract in English by 15 November 1989 to Dorothy Savini, Symposia Operations, ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103–1187, or telephone (215) 299–5413. More information is available from Symposium Chairman Ivan Johnson, 7474 Upham Court, Arvada, Colorado 80003, or call (303) 425–5610.

Air Weather Association Reunion

The Air Weather Service (Army Air Corps/USAF active, retired, prior service, including wx recon) will be holding a reunion 23–27 May 1990 in San Antonio Texas. Non-members can receive more details by writing before January 1990 to Air Weather Association, 5301 Reservation Road, Placerville, California 95667.

Accommodations Available on Ocean Weather Ship "CUMULUS"

Feasibility studies in ancillary utilization of the facilities on the O.W.S. "CUMULUS" are currently being undertaken. Accommodations are available for 52 individuals, of which the current manning is 20 crew (including 6 meteorologists). There is therefore spare capacity onboard the fully equipped dedicated meteorological vessel, which could be used for commissioned oceanographic work, teaching, and research. Anyone interested in using the facilities of O.W.S. "CUMULUS" should contact Captain P.B. Watson, Marine Operations, United Towing Marine Services, Ltd., Boston House, St. Andrew's Dock, Hull HU3 4PR, England.

1990 Meteorological Calendars Now Available

Royal Meteorological Society Calendar

The Royal Meteorological Society has produced a meteorological calendar for 1990. This contains photographs from various world-wide locations. It is available from the Executive Secretary, Royal Meteorological Society, James Glaisher House, Grenville Place, Bracknell, Berks RG12 1BX, U.K. The price for one is \$7.00, or \$25 for five post free.

Australian Weather Calendar

The 1990 issue of the Australian Weather Calendar features 12 color photographs and a variety of information on meteorological phenomena. The calendar is jointly produced by the Australian Bureau of Meteorology and the Australian Meteorological & Oceanographic Society (formerly the Royal Meteorological Society—Australian Branch). Price information and copies of the calendar can be obtained from the administrative assistant of the Australian Meteorological & Oceanographic Society, P.O. Box 654E, Melbourne, Australia 3001. Payment for calendars must be by bankdraft in Australian currency payable to AMOS. Calendars plus airmail cost \$A18.45 for U.S./Canada; \$A19.65 for UK/Europe; and \$15.15 for New Zealand.

Notice of registration deadlines for meetings, workshops, and seminars, deadlines for submission of abstracts or papers to be presented at meetings, and deadlines for grants, proposals, awards, nominations, and fellowships must be received at least three months before deadline dates.—*News Editor* ●