Report on the Surface Analysis Workshop Held at the National Meteorological Center 25–28 March 1991

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Abstract

A Surface Analysis Workshop was held at the National Meteorological Center (NMC) on 25–28 March 1991 primarily to 1) review the status of NMC's surface analysis products in light of the increased criticism expressed by many of those invited to attend, and 2) establish recommendations and guidelines for the implementation of the surface analysis functions on powerful interactive workstations. The workshop also included an analysis exercise conducted under operational time constraints. The exercise provided an opportunity for synoptic meteorologists outside of NMC to gain a better appreciation of the stress imposed on surface analysts by operational requirements and deadlines. Furthermore, the workshop provided 1) a summary of the requirements for operational surface maps and 2) a framework, conceptual design, and associated data requirements for the efficient production of operational surface maps in a computer-based workstation environment.

1. Introduction

The Surface Analysis Workshop was held at the National Meteorological Center (NMC) on 25–28 March 1991. This workshop was held in response to recent concerns raised about the quality of the surface analyses produced by the Meteorological Operations Division (MOD) of NMC. In early 1989, budget reductions and their associated impact on the staff of trained surface analysts accelerated a decision to use automated objective sea level pressure analyses over the United States and Canada rather than subjective hand-drawn isobars. The implementation of the objective analyses resulted in increased criticism of NMC's surface analyses. Numerous letters received at NMC, several formal publications (Bosart 1989; Mass 1991), and a two-month internal review[1] have all cited the degradation of the surface analysis products as a major problem for the National Weather Service (NWS).

[1]The Surface Analysis Review Committee Report (Olson et al. 1991) is available upon request.

The purpose of the workshop was to:

1) review the current status of the surface analysis program at NMC, and to familiarize synopticians from academic and research institutions and NWS personnel outside of NMC with the operational constraints that are imposed upon the surface analyst,

2) establish requirements for centralized surface analysis products at NMC,

3) establish a set of meteorological guidelines for MOD analysts to follow, and

4) establish recommendations and guidelines for the implementation of surface analyses on workstations.

The workshop was structured to 1) allow the participants to make presentations that highlight problems, and propose solutions, 2) provide some time for the participants to observe a surface analysis produced during a regular operational shift, 3) assign the participants a surface analysis exercise under shift-imposed time constraints, and 4) review the work being done at NMC that involves preparing one of NMC's surface analysis products, the Daily Weather Map (DWM), using an interactive workstation (Kocin et al. 1991). The workshop concluded with a series of discussions and plenary sessions to generate requirements and recommendations for improving the analyses produced at NMC.

In this review of the workshop proceedings, a historical overview of the surface analysis function at NMC is presented in section 2, and a brief summary of the workshop presentations is provided in section 3. Section 4 summarizes the activities on the second day of the workshop, when participants were asked to observe or assist in the production of an operational analysis, take part in a surface analysis exercise, and observe a demonstration of the production of a surface analysis on an interactive workstation. Sections 5, 6, and 7 review the requirements, analysis guidelines, and methodology that were established by the various working groups as being necessary for improving the operational surface analyses. Remaining issues are discussed in section 8.

2. Surface analysis products

The suite of surface analysis products produced by NMC/MOD (Table 1) has remained relatively unchanged for the last 20 years. The various surface maps and bulletins are transmitted to a large number and wide variety of users (Table 2) through the facsimile circuits and the NWS "family of services." The three-hourly North American (NA) surface analyses and FINAL (product identifier) Northern Hemispheric surface analyses are archived at the National Climatic Data Center (NCDC).

The general concern expressed at the workshop was that the quality of the operational surface analysis has degraded to an unacceptable level. J. Michael Fritsch's presentation suggested that changes in the NWS philosophy during the past two decades with regard to producing surface analyses (a period of increasing automation and reliance on numerical models) may have played a fundamental role in the degradation of the analysis products. In 1976 the "philosophy of analysis" as stated in the *NWS Forecasting Handbook No. 1* was as follows:

> The intent of the analysis is to depict and identify those features related to weather systems of importance for synoptic scale and ***short-range forecasting*** [emphasis added]. Such systems may be located by parameters in surface reports, or by radar analysis, or by satellite photos. Analyses are smoothed to eliminate the effect of nonrepresentative reports while still retaining details important for forecasting (see *NWS Forecasting Handbook No. 1* 1976, out of print).

By 1979, the rationale for preparing analyses had changed drastically, and this new philosophy of analysis was now reflected as:

> The philosophy of analysis is to use the computer to do the basic work of drawing and redrawing isobars and to have the human analyst monitor, correct, augment, and delete data as necessary to ***provide the computer*** [emphasis added] with sufficient information to accurately depict the sea level pressure field, especially in regard to depth and position of storms. The analyst's intervention is based on continuity, persistence, vertical consistency and the evidence of satellite pictures, particularly as to locations of storm centers at sea. The analyst decides on the location of fronts based on these principles as well as the reported data and digitizes the fronts in one of the ways described in Section 2.4, North American Surface Analysis (see *NWS Forecasting Handbook No. 1* 1979, out of print).

The change in emphasis between these statements is significant in that it reflects a trend from viewing surface analyses as a crucial tool for properly depicting and understanding the synoptic-scale situation and for making short-term forecasts, to viewing it as a product that is important only for objective analysis schemes and initiating models.

The 1970s also marked a turning point in the production of surface analyses as the NWS management acted to reduce the resources required to generate operational charts, therefore requiring the automation of many products. Until 4 November 1975, the surface analysis program at NMC [including the 3-hourly NA, 6-hourly Northern Hemisphere (NH), and 6-hourly tropical analyses] was based entirely on manual plotting and analysis. Data plotting required 10 meteorological technicians on each of four separate crews. Map analysis required three analysts on each of three shifts per day, with two additional analysts per day for the analysis of tropical regions. The automation of the plotting in the 1970s had its desired effect as the number of meteorological technicians

TABLE 1. Surface analyses produced by NMC/MOD

Three-hourly North American surface analysis with data This product has an automated pressure analysis with manually analyzed fronts and other surface systems and is archived by NCDC.
Frontal analyses These are encoded from the North American analyses and are transmitted in bulletin format.
Six-hourly Preliminary (PRELIM) Pacific and Atlantic oceanic analysis with data These maps are produced using manual analyses.
Six-hourly Tropical Analysis This product is an automated streamfunction analysis that is augmented by the addition of tropical storm information.
Twelve-hourly FINAL Northern Hemisphere Analysis This product is a revision of the PRELIMs, based on later data. The maps are carefully drafted and are submitted to NCDC as the official archived record of Northern Hemisphere weather systems.
Storm Tracks The location and intensity of storm centers are extracted from the 12-hourly FINAL analyses and appear in *Mariner's Weather Log, STORM DATA* and are archived by NCDC.
Daily Weather Map Once per day, the 1200 UTC analysis over the U.S. and adjacent regions is carefully reanalyzed and drafted for publication.
Congressional Map Display When Congress is in session, the 0600 UTC analysis is carefully drafted onto prepared base maps for display in the House and Senate, in addition to selected forecast material.

assigned to this task decreased significantly.

However, the retirements of several key individuals and a perceived lack of management interest in the surface analyses being produced at NMC also resulted in a general degradation of the product during this period. In 1985, the retirement of another branch chief within MOD resulted in the merger of the surface analysis group with those responsible for producing the daily forecast products, creating the present Forecast Branch in MOD. The surface analysis became an integral part of operations within the Forecast Branch, with forecasters standing a regular watch at the analysis table and the senior branch forecasters monitoring the products daily. This did not resolve all of the difficulties, but it did elevate the function to a newer role, as short-range quantitative precipitation forecasters in MOD began emphasizing the importance of a high-quality surface analysis for their forecasting activities.

TABLE 2. Principal users of the surface analyses produced at NMC

Government	Nongovernment
NOAA	Universities/colleges
• National Weather Service	
• Central Weather	Private meteorological services
• National Environmental Satellite, Data and Information Service	Media
—Satellite Analysis Branch	
—National Climatic Data Center	International (principally through WMO)
Department of Transportation	Individual/high seas and on-shore shipping
• Federal Aviation Administration	
• Coast Guard	Legal
Department of Defense	Fisheries
• Air Force	
• Navy	Recreational
• Army	
• Marines	
United States Department of Agriculture	

In 1989, further budget cuts imposed severe constraints on the surface analysis program by the implementation of an automated sea level pressure analysis (that can not be manually adjusted) on the NA charts and splitting responsibility for manual production of the NH surface analyses between the Forecast Branch and a marine forecast group in MOD. The automated isobars have not been viewed favorably by a large number of meteorologists within and outside of NMC (Bosart 1989). Furthermore, the split responsibility proved to be unmanageable, a situation that was made even more difficult by the increasing forecast responsibility taken on by the marine forecast group.

The problems noted above were compounded by the transfer of NWS products to the Automation of Field Operations and Services (AFOS) system in the middle 1970s. Before the advent of AFOS, when all NMC products were delivered by facsimile, NMC surface analyses were one of the most important charts in the map displays at all the NWS forecast offices. However, no provision was made to transmit these surface analyses to AFOS sites, a decision that removed NMC's surface charts from the local forecast offices. With one of the largest segments of the forecast community now unable to receive these charts, their importance within the NWS was significantly reduced.

The debate over the value and use of surface analysis products within the NWS is motivated by the large amount of resources required to support manual analysis procedures and the questions concerning the value of these maps, especially when local NWS forecast offices are not receiving them.

The issue of assessing the importance of performing analysis functions is also illustrated by an interview with Jule Charney (Platzman 1990). Charney states his displeasure with the prospects of having to do an analysis:

> I hated the laboratory when I took the course, because I couldn't see the sense in spending so much time drawing maps. . . . The theory in those days was that only in this way would you familiarize yourself, sort of at first hand, with the meteorological situation. I spent a lot of time plotting maps. That was part of my chore and, you know, to me that was a total waste of time. (p. 20)

Later in that same interview, he notes that, despite his initial impressions that analysis was a "waste of time," he later appreciated the importance of doing analyses:

> I'm very grateful for having been exposed so very directly to actual atmospheric phenomena. (p. 20)

He then goes on to state,

> I think a person who has made subjective analyses of weather maps has a deeper appreciation of how inadequate

> many objective analysis schemes are, and if you simply accepted the machine product as reality, it would be very dangerous. And I think that the tendency to rely too heavily on the machine has occasioned a lot of errors in operational work, and not only in operational work, but in research, synoptic research.
>
> In other words, I think it's more than a mystique that one must be exposed to the data, and precisely how to do that isn't clear. But at the same time I would agree very much that machines can be used very constructively to produce various kinds of analyses so you could look at the essentials of the atmosphere. (p. 21)

Other forecast offices have also been confronted with the nonscientific aspects of surface analysis, as indicated by the following excerpt from a United Kingdom Meteorological Office (UKMO) publication:

> It has been said that synoptic meteorology is imbued with as much art as science. This is certainly true of the analyzed synoptic chart. Nature is at heart an artist and the smooth, functional lines and colours of the synoptic chart show ample evidence of this truth. Now it is obvious that every meteorologist is not also a skilled artist. Nevertheless this is no reason for untidy or sloppy work. The final chart should have artistic beauty and give pleasure to the eye of the viewer. If the frontal lines and isobars are smoothly drawn and properly spaced and colour is skillfully injected, the chart should have some of the beauty of a painting or other work of art. Anyone who has seen work at its best will realize the inherent truth of this. *A synoptic chart so drawn will convey at one glance something of the working of the atmosphere to the viewer.* (UKMO 1964, p. 19)

The need to resolve these issues with respect to providing operational surface analyses, the desire to focus our efforts on providing a quality product that is an important component for the production of forecasts both in and out of NMC, and the requirement to introduce computer-based methods to minimize costs and standardize the quality of operational products provided the major motivation for conducting this workshop.

3. Participant presentations

A number of the participants representing a broad spectrum of the meteorological community were provided the opportunity to address the workshop, including Frederick Sanders, Kenneth Mielke (representing all of the NWS regional Science Service division chiefs), Clifford Mass, Richard Reed, Melvyn Shapiro, Lance Bosart, Steven Koch, Michael Fritsch, and Stanley Benjamin. Although their presentations covered many aspects of the problems associated with NMC's forecast and analysis products, they were unanimous in their recognition of the importance of NMC's role in producing accurate and timely analyses and forecasts as a basic service to the country.

Sanders' and Mielke's presentations were directed at the historical aspects of the surface analysis program. Sanders drew upon his recent experience at NMC to emphasize that modifications to several plotting routines (especially as they pertain to positioning reports from ships and buoys), and the use of an 8-mb interval for oceanic analyses could both be instituted in relatively short order and save quite a bit of time for the analyst. Sanders also stressed his observations that there is a lack of temporal continuity in NMC surface analyses, especially for the oceanic products, a problem compounded by poor objective analyses (see also Sanders 1990) and the misinterpretation of satellite imagery.

Mielke's presentation made clear that not having the NMC surface analysis in NWS offices around the country has had a tremendous negative impact for NMC. Currently, NWS personnel in most of the local forecast offices do not see the NMC manual analyses transmitted over facsimile, and therefore do not consider this product to be of any importance. Yet the positions of fronts and major high and low pressure systems produced by MOD and transmitted by AFOS are "looked at" in NWS offices, especially for "self briefings" as forecasters come on shift, and for any aviation briefings they might give. Nevertheless, the impact of these frontal analyses, which are available through AFOS, in local forecast offices was not addressed directly but is presumably small.

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A number of presentations dealt with an overreliance on the use of the Norwegian model for surface fronts that dates back to the 1920s (Bjerknes 1919; Bjerknes and Solberg 1922), a point recently emphasized by Mass (1991). Mass repeated this contention at the workshop and showed examples where the simple frontal models completely broke down. Mass, Bosart, Fritsch, and Koch all built upon this point to stress the need for more mesoscale detail in the NMC products, especially for the NA charts. Koch stressed the need for detailed analysis of the evolution of fronts and dry lines as they relate to severe weather events. Bosart demonstrated the importance of the proper analysis of inverted troughs, usually extending northward from low pressure centers, and their impact on the distribution and type of precipitation. The importance of analyzing for mesoscale detail was also emphasized by Fritsch in his description of the impact that a fast-moving front over mountainous terrain might have had on the crash of a small private airplane.

The call for mesoscale detail in the surface charts produced in a central facility generated much debate among the workshop participants. Indeed, exactly how much of the detail could be incorporated into the NH and NA charts would have to be judged very carefully before such changes can be instituted on an operational basis. There was also a wide range of opinions on the symbology needed for operational charts. Mass, Fritsch, and Koch argued for the introduction of new mesoscale symbols and lines to identify important small-scale features such as outflow boundaries and coastal fronts. On the other hand, Sanders and Bosart argued for the elimination of fronts and other boundaries from the current charts and to "let the wind and temperature fields speak for themselves." The general consensus that was reached was not to rush into the use of new mesoscale symbols and not to drop fronts altogether, since the analyzed fronts draw the attention of those viewing the maps to specific areas of noted airmass contrasts and associated weather-producing systems. The heavy reliance of the diverse user community on NMC products based on conventional methods and nomenclature suggests that any changes made to the way operational charts are analyzed should be limited in scope and not be so drastic as to overhaul existing analysis guidelines, especially with respect to fronts.

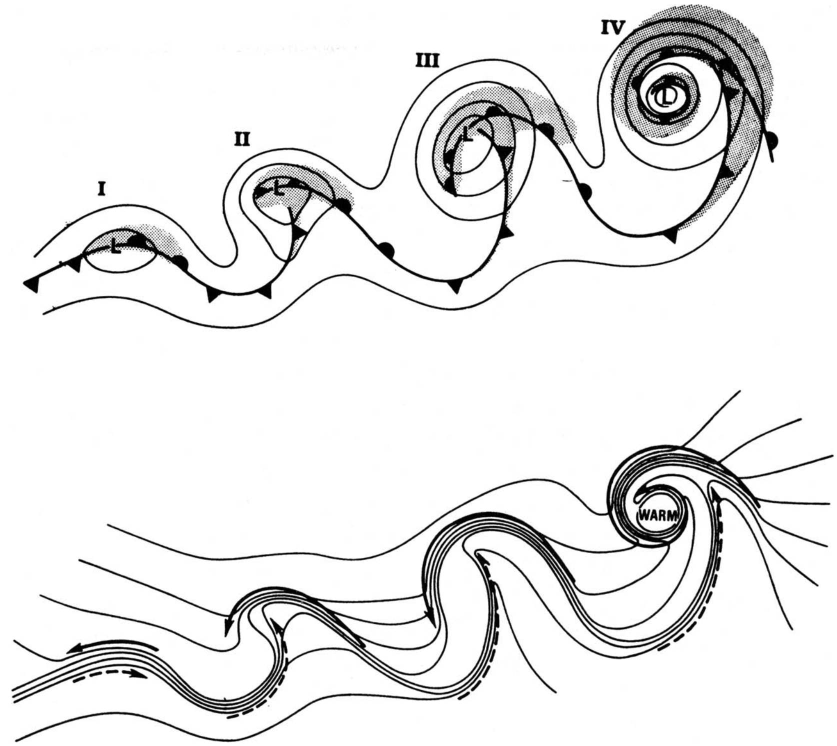

FIG. 1. Proposed life cycle of the marine extratopical frontal cyclone: (I) incipient frontal cyclone; (II) frontal fracture; (III) bent-back warm front and frontal T-bone; (IV) warm-core frontal seclusions. Upper: sea level pressure, solid lines; fronts, bold lines; and cloud signature, shaded. Lower: temperature, solid lines; cold and warm air currents, solid and dashed arrows, respectively (from Shapiro and Keyser 1990).

Shapiro's presentation dealt with the shortcomings of the Norwegian model but in a different vein from the viewpoint offered by Mass. Drawing upon the recent article by Shapiro and Keyser (1990), he noted that the Norwegians were quite aware of the complexities of the fronts accompanying major cyclones that affected the European continent, and also recognized the limitations of the schematic models they produced. Shapiro then used recent research-aircraft observations and model-based diagnostic studies to propose modifications to the Norwegian model, rather than discarding it. These include the concepts of a "frontal fracture," "bent-back warm front," "frontal T-bone," and a "warm-core seclusion" (see Fig. 1). While there was not immediate agreement among all of the workshop participants about adopting these modifications, the forecasters from NMC appear to be enthusiastic about adopting these concepts.

A number of the presentations built upon the findings of the NMC Internal Review Report (Olson et al. 1991) to stress the poor quality of the existing automated sea level pressure analysis and the inability to modify this analysis as the fronts and trough lines are manually drawn on the charts. Mass, Bosart, and Reed stressed these factors in their presentations and, along with Benjamin, called for improved first-guess fields to be made available to the NMC analyst. As part of the objective analysis issue, Koch emphasized his belief that no objective analysis scheme can account for the mesoscale detail near the surface and that *manual intervention will always be necessary.* Benjamin also noted the issues associated with the problem of sea level pressure reduction over the mountainous terrain in the western United States and proposed that the pressure reduction techniques described by Benjamin and Miller (1990) be tested in an operational environment.

Another important issue touched upon by many of the presenters, but most forcibly by Reed, involves the training of the surface analysts. Several problem areas were noted, including the perception that synoptic meteorology and analysis procedures are being given decreasing attention by the universities around the country. Reed recommended that a dedicated team of enthusiastic analysts be reinstated in NMC, a proposal that paralleled ongoing discussions within the MOD prior to the workshop. Furthermore, he recommended (along with Mass and Fritsch) that a training manual be developed for NMC interns and that surface analysis be made a critical component of the intern training program.

4. Participant experience in MOD

On Tuesday, 26 March 1991, the workshop participants were divided into three groups and rotated through the following activities: 1) a viewing of the preparation of operational surface charts, 2) participation in a surface analysis exercise under operational time constraints, and 3) a demonstration of the application of the Intergraph workstation to the preparation of the DWM.

a. Description of the shift experience

The three groups each spent about two hours at the surface analysis table. Each group was able to participate in or view the production of an NA analysis. Two groups viewed the production of the preliminary NH map (Table 1), and the third viewed the production of a final hemispheric analysis to be archived at NCDC. Throughout the day, the participants were able to see how the VAS Data Utilization Center (VDUC workstation; see Mostek and Siebers 1987) and the NESDIS Electronic Animation System (EAS) were used to access still and animated satellite imagery [including image products from the Meteosat (European) and the GMS (Japanese) geostationary satellites] as input into the analyses, particularly over the data-sparse ocean regions. They also observed the variety of supporting upper-level analyses and short-period (e.g., 6-h and 12-h) model forecasts that were available for the analysts' use to ensure vertical and temporal continuity. An important goal of the demonstration was to expose each group to the pressure of very tight deadlines and the quantity of work required to meet those deadlines.

The participants were of two different types: some were content to watch, while others were willing to become involved with the analysis process. Those who became actively involved carefully examined other maps, reached their own decisions about frontal locations and made some comments about the procedures. Most of the participants appeared to develop an appreciation for the amount of work and stress involved to complete these maps due to the short time limits imposed by the operational product delivery schedule.

b. Summary of the surface analysis exercise

The workshop participants were asked to analyze an NA and an NH surface chart as part of a surface analysis exercise. The purpose of the exercise was to 1) familiarize participants with the operational time constraints that exist at NMC, 2) address the question of what should be routinely analyzed, and 3) illustrate some of the limitations of the Norwegian frontal model.

Individuals were allowed 40 minutes to analyze an NA chart and an hour to analyze either the Atlantic or Pacific half of the NH map. The participants were encouraged to analyze the features they would like to see included on an NA surface chart. Individuals were also told to use symbols that they have proposed for operational use to describe any synoptic or mesoscale features that are not adequately represented by the current frontal and weather depictions.

The most significant impression gained from the exercise was the wide variety of opinions on what structures could be designated as fronts and what kinds of mesoscale features should be analyzed on either the NH or NA charts. This led to significant differences in how the participants analyzed their individual maps. Several individuals tried analyzing isobars and isotherms without using frontal symbols, or simply analyzing streamlines and isotherms. Most retained the more conventional isobars, isotherms, fronts, and troughs.

The various features analyzed by the participants for the 2100 UTC 13 February 1991 NA Map are shown in Fig. 2, with fronts depicted by solid lines. Other features such as surface troughs, squall lines, and fronts undergoing frontolysis are shown by dashed lines. Even with the dense data coverage over the United States, a wide range of frontal positions was analyzed. Some analysts placed a warm front along the southern edge of the 1000–500-mb thickness gradient (not shown) over the southeast United States, where surface temperatures changed from 60°F (14°C) or above to the upper 50s. Others placed the front

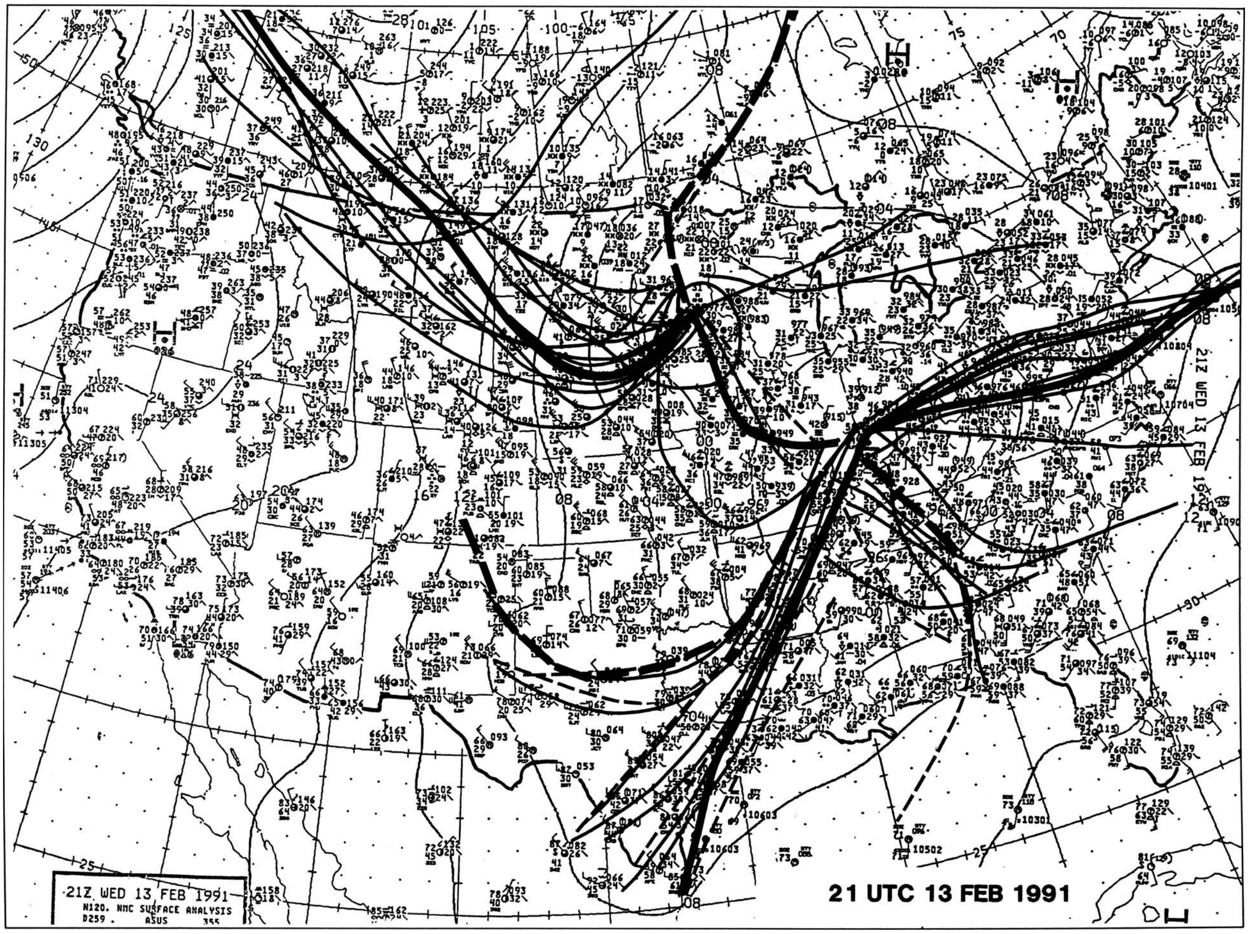

FIG. 2. NMC North American surface data plot for 2100 UTC 13 February 1991; fronts analyzed by the workshop participants are shown as solid lines, other surface features such as troughs, squall lines, etc., are shown as dashed lines. Lighter solid lines are objectively analyzed isobars (4-mb intervals). The NMC fronts and troughs are shown by thicker lines.

along the southern edge of the strong thermal gradient located across the Mid-Atlantic states.

The analyses of the arctic front extending across the Northern Plains also varied, with a spread of over 300 km between the two most different positions. One individual interpreted the data as showing two arctic fronts, one over Nebraska and another north of Lake Winnipeg. The analyses also differed significantly over Texas. Some placed a cold front across northern Texas near Abilene, where low-level cyclonic shear was present. Others placed the front closer to San Antonio, while still others placed the front along the Texas coast, the leading edge of a stronger dewpoint gradient. Several participants analyzed for multiple fronts or chose to call the boundary along the Texas coast a dry line.

Finding a universally accepted frontal analysis over Texas was difficult because the cyclone over southern Indiana and its accompanying fronts evolved in a manner that was significantly different from the Norwegian model (Bjerknes 1919; Bjerknes and Solberg 1922). The primary low formed in the lee of the Rocky Mountains. The low and an associated surface pressure trough then moved east, such that by 1200 UTC 13 February 1991 the trough was located across west-central Texas, with temperatures behind it no cooler than those ahead of it.

By 1500 UTC 13 February (not shown), frontogenesis was taking place within this trough, and another pressure trough formed along the Texas coast. A dewpoint discontinuity developed along the coastal trough during the day. By 1800 UTC (not shown), the dewpoint discontinuity associated with this trough was in the process of merging with the dewpoint discontinuity associated with the initial trough to the west. Workshop participants had to decide on the location and definition of each boundary and how to analyze it. The cyclonic shear zone across northern Texas with slightly cooler temperatures to its north further complicated the situation. This confusing array of information provided the participants with a sense of the difficult decisions operational analysts have to deal with every day.

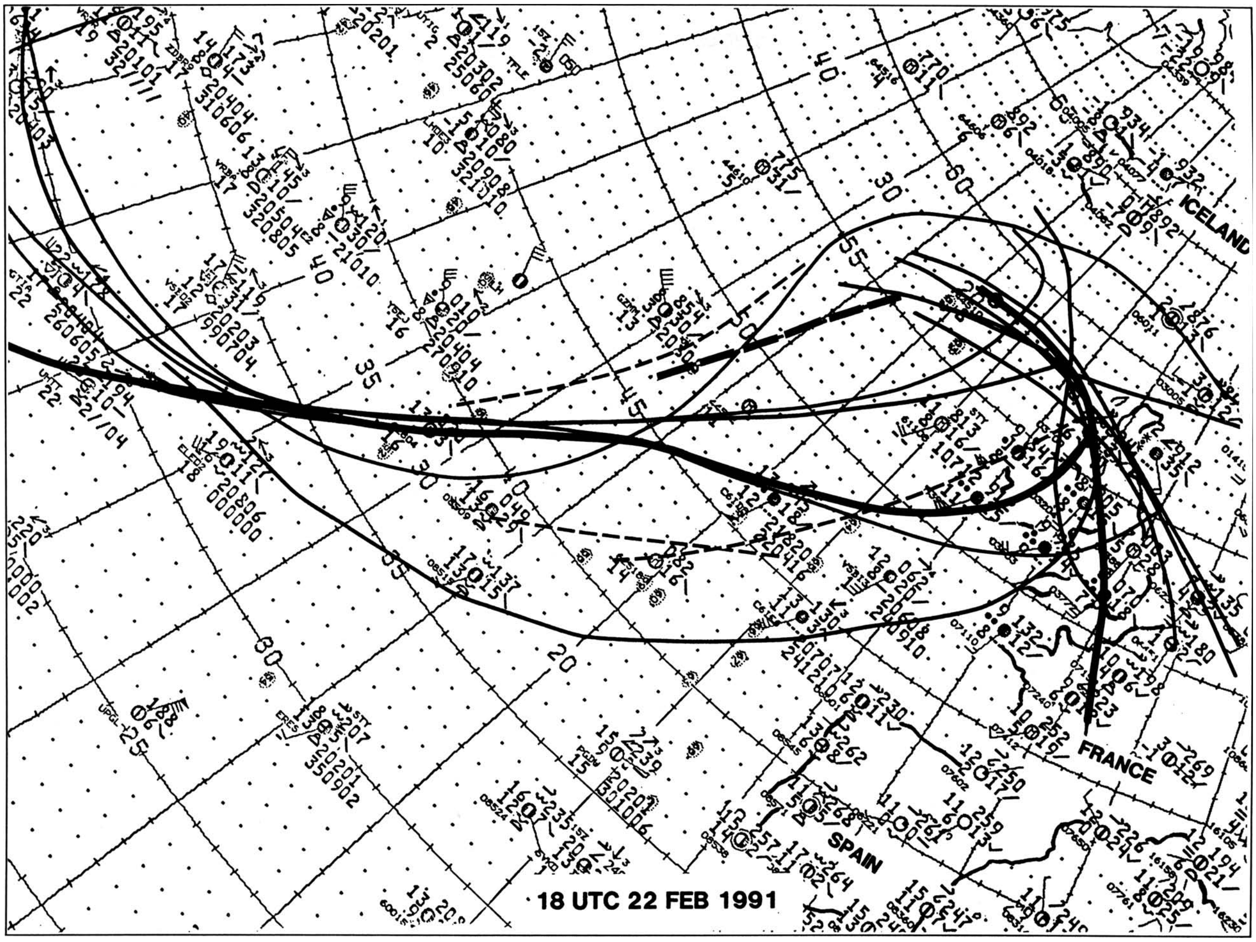

FIG. 3. North Atlantic surface data plot for 1800 UTC 22 February; fronts analyzed by the workshop participants are shown as solid lines, other surface features such as troughs, squall lines, etc., are shown as dashed lines. The NMC fronts and troughs are shown by thicker lines.

The workshop participants appeared to share many of the same difficulties analyzing the frontal systems over the United States that frustrate NMC operational analysts, as noted in the Surface Analysis Review Committee Report by Olson et al. (1991). The wide variation in analysis solutions by the participants suggests that analyses produced by experienced synopticians can suffer the same lack of temporal continuity that has been recently documented in NMC analyses by Mass (1991), especially when placed in an operational setting with strict time constraints.

The frontal positions analyzed by the participants for the eastern Atlantic portion of the 1800 UTC 22 February 1991 NH charts are shown in Fig. 3. Fronts are depicted as solid lines, with the troughs and decaying fronts depicted as dashed lines. Differences between the analyzed frontal positions west of the British Isles sparked several spirited discussions, the most notable between Reed, Sanders, and Shapiro over the location of the cold front. The discussion centered around the question: Should the front be analyzed over Ireland, where pressures were rising and steady rain was falling, or had it reformed to the west, where considerable low-level cyclonic shear was located? The frontal positions differed by as much as 1000 to 1600 km. It is interesting to note that experienced synopticians arrived at very different frontal solutions over the North Atlantic Ocean, where the Norwegian model was developed and should be most applicable. The differences illustrate the complexity of surface analysis and the need to exercise caution when applying conceptual models to the analysis of weather systems.

The frontal positions analyzed over a portion of the Pacific Ocean are shown in Fig. 4. The chart is noteworthy because only a few ship reports were plotted on the 1800 UTC chart, making satellite imagery the primary tool in the analysis process. The two separate clusters of solid and dashed lines in Fig. 4 represent the location of two different frontal systems. The cluster just east of the dateline was a strengthening frontal system associated with a developing cyclone. Analyzed frontal locations for this front/trough varied by as much as 650 km.

Analysts had two problems to reconcile in locating the westernmost feature: 1) the lack of reliable ship data (the ship UUPB plotted nearest the front may have been misplaced), and 2) the proper interpretation of satellite imagery. An ill-defined but discernible cloud pattern in the satellite imagery was associated with this feature (not shown). These two difficulties led to additional analysis problems: 1) what to call the system, a trough or a front, and 2) where to locate the surface feature that was associated with the weakly organized cloud pattern. The analyzed positions of the system differed significantly. The extreme eastern solution was located at 40°N, 167°E, and the extreme western one at 40°N, 154°E, a difference of about 1300 km.

The widespread differences in the location of the analyzed fronts over the Pacific indicate a deficiency in our knowledge of where to place a front based on satellite imagery, and suggest that the interpretation of satellite imagery differs even among the experts. The analysis differences also indicate a need for the development of conceptual models that account for the most likely position of a front based on cloud distribution, especially over data-sparse oceanic areas.

Prior to the workshop, NMC operational meteorologists analyzed the same set of charts that was analyzed by workshop participants. The NMC frontal positions for the 1800 UTC 22 February NA map are shown in Fig. 2 by the thicker set of lines, and for the Atlantic and Pacific maps in Figs. 3 and 4. The NMC positions of the fronts generally fell within the envelope of positions analyzed by the workshop participants, usually near the middle of the various frontal positions.

All the groups appeared to have difficulty completing the analyses in the allotted time, as illustrated by the relatively few frontal positions over the western Pacific Ocean (Fig. 4). Several participants stated that more than one person was needed on a map to complete a quality analysis. Most of the participants appeared to have gained a better appreciation for the impact of the severe time constraints on the production of operational meteorological analyses.

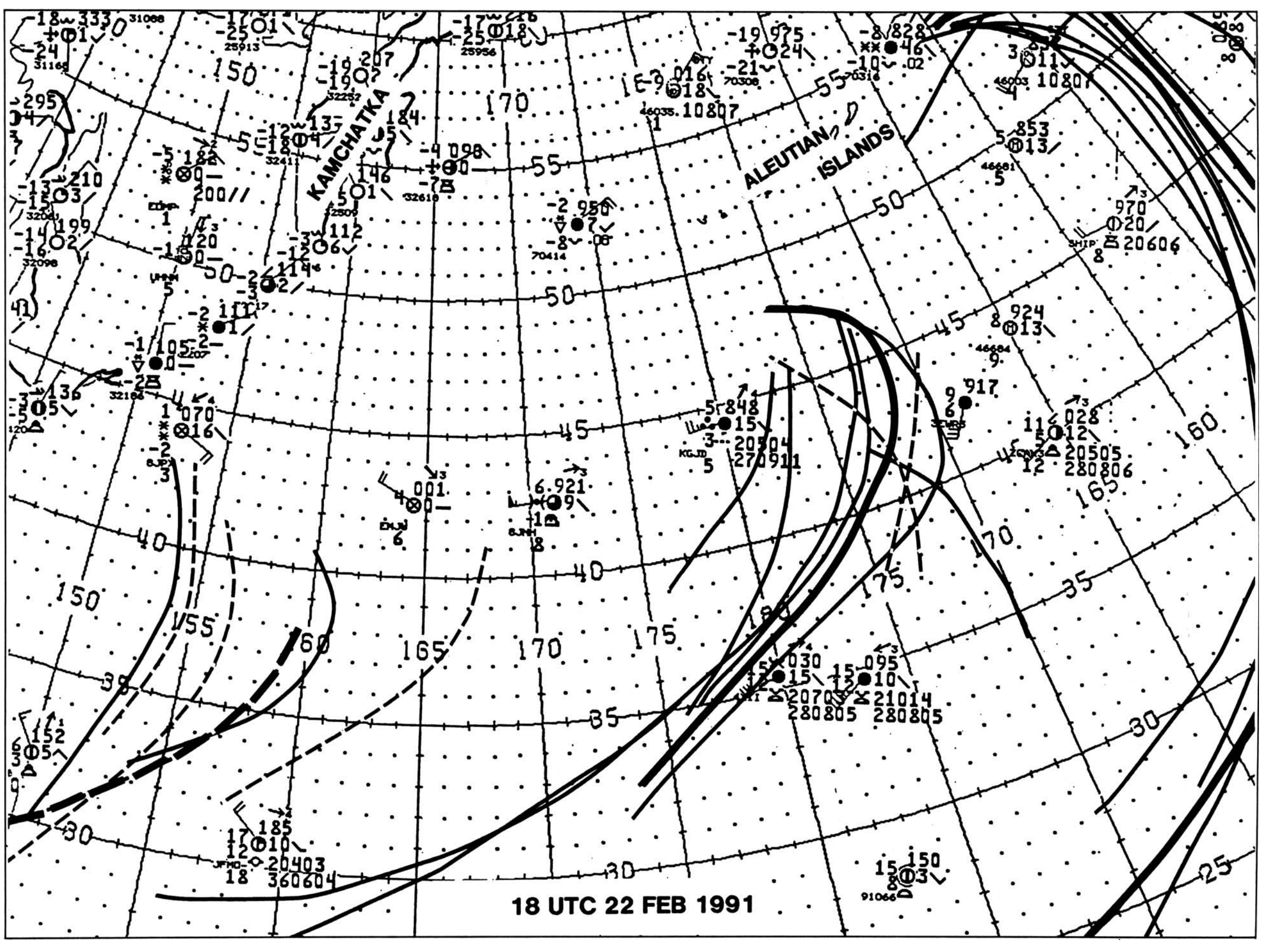

FIG. 4. Same as Fig. 3 except North Pacific surface data plot for 1800 UTC 22 February 1991.

c. Workstation demonstration

Paul Kocin conducted demonstrations of the Intergraph workstation that is used to generate the surface weather analysis for the Daily Weather Map publication. As part of the demonstration, all of the workshop participants had an opportunity to experiment with preparing a surface analysis on the workstation.

Participants were first shown how a surface analysis used for the DWM was generated on the Intergraph Interpro 6240, a procedure that is described by Kocin et al. (1991). This workstation is a UNIX-based system with a 27-inch, high-resolution color display, and is rated at 14 million instructions per second. The demonstration involved the drawing and placement of fronts and contours, including isobars and isotherms, placement of text and storm tracks, and the ability to turn on and off auxiliary datasets, including several first-guess files of sea level pressure isobars based on the operational Cressman analysis and the MAPS analyses from the Forecast Systems Laboratory (Benjamin and Miller 1990). Other files available on the workstation included the entire set of NA surface observations, surface frontal positions, cyclone and anticyclone centers, and the operational radar summary chart.

Surface analysis charts remain a crucial element for the assessment of current weather conditions and represent an important first step in making short-range weather forecasts.

Preparation of the surface analysis is accomplished on the Intergraph using a mouse and menu-driven user interface. The analyst selects commands from an on-screen menu through use of a mouse, and then draws utilizing the mouse. "Drawing" on the workstation involved either modifying a machine-drawn set of text and contours based on gridded data or forecast fields, drawing the contours directly, or entering text and labels. The ability to generate a surface analysis with a great degree of detail and control over the spacing and curvature of contours was also demonstrated. An example of a surface chart prepared for the DWM utilizing the Intergraph workstation is provided in the cover figure.

Following the demonstration, workshop participants received hands-on experience in preparing some of the charts for that day. There was considerable variation in the abilities of the participants to utilize the workstation, especially in drawing with a mouse. Nevertheless, most participants seemed to feel that the workstation approach was the "way to go" to provide an operational surface analysis of the future.

5. Requirements for NMC surface analysis products

The workshop participants unanimously agreed that NMC must adopt the 1976 NWS analysis philosophy discussed in section 2 as a basis for the requirements of the surface analysis products produced at NMC. They recognized that surface analysis charts remain a crucial element for the assessment of current weather conditions and represent an important first step in making short-range weather forecasts. If done proficiently and transmitted to *all* of the potential users in a timely manner, the surface charts produced by NMC would regain their important status as one of the more critical operational weather charts.

The specific requirements for the NH and NA surface maps include the provisions for:

- a consistent synoptic overview for NWS field offices that meets community needs as specified by other government agencies, the military, international and private-sector meteorologists, and the university community,
- input for aviation support (especially for flight weather briefings) and the transportation industry in general (including high-seas shipping),
- accurate analyses for the initiation of MOD forecast products (high-seas forecasts, quantitative precipitation forecasts, and basic weather forecasts),
- improved model initialization through bogusing and quality control efforts,
- an accurate and complete long-term archive of weather systems that remain as an important baseline of the long-term climate record, a requirement that includes the production of the DWM series, and
- the training for the meteorological interns or trainees within MOD.

Ultimately, the surface analysis should provide an accurate database for the initiation of local analyses and forecasts at the NWS weather forecast offices (WFOs). This means that the isobars must be produced on a timely basis in a gridded (easy to access and modify) format that can be transmitted to WFOs through the Advanced Weather Interactive Processing System (AWIPS) of the future.

6. Analysis guidelines

The workshop participants agreed that the NMC surface analyses should depict the evolution or life cycle of weather systems in a manner that is consistent with the three-dimensional structure of atmospheric features, especially those involving the moisture, wind, and thermal distributions. The Norwegian frontal model is still considered a viable concept that can be used where appropriate, with the recognition that certain modifications should be considered. While forecasters in MOD seem willing to accept the modifications to the Norwegian frontal model proposed by Shapiro and Keyser (1990), there was some disagreement among the workshop participants as to the applicability of some of the new or modified concepts (such as "frontal fracture," "bent-back warm front," "frontal T-bone," and "warm-core seclusion") to a large number of cases. In any event, workshop participants agreed that certain synoptic and mesoscale features should be included on the NMC surface charts. The specific recommendations made for the NA and NH charts are discussed below.

a. Northern Hemisphere analyses

Northern Hemisphere (NH) surface maps are produced on a polar-stereographic projection with a scale of 1:20 m. All data over land masses should be accessible to the analyst, even though data plots may be filtered to avoid overlap. Except for reports near the coastline, all ship/buoy data received by the data cutoff time is available to the analyst, either plotted on the map or in the margin with a small circled reference number at the ship or buoy location. The preliminary Atlantic and Pacific analyses are done every 6 h from a computer data plot generated 1 h and 40 min (1+40) past data time and scheduled for delivery about 4 h and 40 min (4+40) to users. The final analyses are produced for the historical archive every 12 h from a data plot generated 4 h and 20 min past data time (4+20).

The scale of surface systems to be analyzed on the NH charts must be consistent with the map scale, data coverage, and analysis frequency. This scale, coverage, and frequency are such that this chart must be defined as basically a synoptic-scale analysis. However, certain mesoscale features such as cold-core polar lows and coastal fronts may be analyzed when they can be properly identified and are expected to persist. The sea-level pressure analysis is carefully constructed to provide as accurately as possible the position and depth of cyclones, the pressure gradients over the oceans, and accurate locations of fronts.

b. North American analyses

The 3-hourly NA analyses are produced on a polar-stereographic projection with a scale of 1:10 m. Data is plotted at 20 and 40 min past the hour (0+20) and (0+40). The analyst also has intermediate hourly plots of data available for inspection. By 0+40, nearly all buoys are available and a few ship reports are available. The coverage of plotted data over the United States is about four times as dense over land areas as that of the NH maps. The plot and analyses that are transmitted are also archived at NCDC.

The NA maps will include a blend of synoptic and mesoscale pressure analyses to account for convective systems when the current automated pressure analysis is modified or replaced by a manually modified pressure analysis. The analyses will also include:

- fronts (primary, secondary, arctic, and coastal),
- troughs (when indicated by the pressure/wind field),
- drylines,
- squall lines, and
- outflow boundaries.

A variety of airmass sources are found over North America. Thus, the Norwegian frontal concepts may not be totally adequate to explain the variety of systems encountered over the continental United States. The analyst must be encouraged to recognize the complexities involved with the mesoscale structure of fronts and drylines, and accept that these features and evolution will not always conform to simplified schematic representation.

7. Recommendations on methodology

A methodology working group came to the unanimous conclusion that all surface analyses should be done on workstations. They recommended an acceleration in the development of a pre-AWIPS-era workstation that meets the requirements for operational surface analyses, with the system design meeting AWIPS standards. Many members recognized that there were many short-term changes that could be made, such as plotting more ship observations in their actual location rather than in the margin of the chart, and providing time series of ship and buoy observations to help assess their accuracy. Efforts to implement these short-range improvements would depend on whether the changes would require excessive software development, or whether the changes would have a negative impact on the plans to switch analysis to a workstation environment.

a. Manual versus objective analyses

The recommendation to apply workstations to the surface analysis problem is based on the concept of taking advantage of the potential for time savings associated with objective analysis while still providing for manual oversight and quality assurance, thus avoiding the large resources usually associated with this product. A description of some of the issues impacting manual and objective analyses follows.

1) Manual analyses

(i) *Advantages.* The process of preparing analyses on paper by hand is by itself an important component of generating a forecast, because an eye–hand analysis with paper and pencil ensures that an analyst carefully, and completely, examines the data and understands the evolution of weather features. When done properly, manual analysis can provide tremendous insight into meteorological processes. Subsequent communication between analyst and forecaster is a crucial link for short-range diagnosis and forecasts.

(ii) *Disadvantages.* The current system of manual surface analysis at NMC is inflexible and archaic, involving considerable time, materials, and expense. The operations schedule dictates that much of the time used preparing the surface chart is spent not on analysis but on labor and materials, requiring the service of numerous individuals to retrieve charts, paste them together, make copies, maintain copying machines, and supply the necessary acetate overlays and supplies. Data ingest, flow, and display are inflexible. Different types of data (land, ship, buoy) are hard to distinguish and difficult to examine in data-dense areas.

2) Objective analyses

(i) *Advantages.* Objective analyses of sea level pressure over NA drastically reduce the time needed to produce a surface analysis, either as the analysis or as a first guess. The analyses exist in a form that is readily compatible with numerical forecast systems and other programs such as those dealing with verification and quality control systems.

(ii) *Disadvantages.* While the objective analysis saves time, it is presently inferior to professional, manual surface analysis (see, e.g., Sanders 1990). Statements were made at the workshop that objective analysis techniques applied to surface analysis will never replicate the skill of a trained analyst. The variable density, quality, and type of data impacts the analysis. The use of the objectively drawn isobars can also detract from the analyst's ability to recognize subtle yet important features in the data. At present, the objectively analyzed isobars cannot be modified. Fronts that are drawn without associated modifications to the isobar pattern sometimes result in nonmeteorological and inconsistent analyses that look unprofessional. The objective analyses are often unrealistic over the data-sparse oceanic and continental areas, which can be extremely misleading to both analysts and users.

3) Workstation recommendations

A properly designed surface analysis function developed on powerful workstations can take advantage of the benefits of both manual and objective analyses by:

- allowing the analyst the flexibility of modifying machine-derived objective analyses
- providing ready access to gridded fields, standard surface observations, and satellite imagery, with the analyst able to view the hourly objective surface analyses and observations in a real-time mode
- providing the analyst with a complete three-dimensional dataset
- eliminating manual and repetitive tasks
- providing a more professional product that can be standardized (consistent line width, consistent labeling)
- improving the flow of data and finished products through the system
- assuring time continuity in the analysis products
- allowing experimentation with new analyses and data sources.

As outlined in Fig. 5, the analyst should have access to automatically plotted and objectively analyzed hourly surface maps. From an hourly sequence and access to other data and model output (e.g., satellite imagery and short-term forecasts), the 3-hourly NH maps, 6-hourly NA maps, and 24-hourly DWM would be extracted for modification and enhancement by the surface analysts. Determining the possible analysis techniques and numerical models that could provide the best hourly sequence of objectively analyzed maps will require an extensive period of testing. Indeed, several debates among the workshop participants concerned the relative value of objectively analyzed fields given the accuracy and mesoscale details inherent within the wind and temperature fields produced by numerical forecasts, especially those provided in the 0- to 24-h range.

All other recommendations are made in conjunction with development of the workstation. These include the following corollary recommendations.

b. Datasets required

The following datasets are necessary for preparing a meso-alpha–scale surface analysis:

- all surface data [land, ship, buoy, Automated Surface Observing System (ASOS) and other datasets, including oil rigs],
- model first-guess fields and 3-h multivariate analyses over the oceans, with the fields provided from a suite of models,
- a full depiction of the upper-level analyses,
- animated satellite imagery and radar data,
- ability to handle special datasets as they come on line,

- time series of individual station reports, and
- diagnostic computations, possibly based on the UNIX version of GEMPAK 5.0.

c. Improved first-guess field

There were no specific recommendations concerning which objective analysis should be used as a first-guess field. There was, however, general agreement that various fields should be examined as the workstation development evolves. Several questions were raised, including what to do about differences in analyses over land versus oceans (consider use of a univariate or multivariate analysis or combination of both), and what are the roles to be played by short-range numerical models in providing a first guess for surface analyses. Clearly, some of the work presently done by the Forecast Systems Laboratory on the MAPS system (Benjamin 1989; Benjamin and Miller 1990) needs to be evaluated at NMC.

d. Quality control

There was a clear consensus for the requirement to quality control data and analyses as part of the surface analysis production cycle. This recommendation is more general, but the group suggested that NMC provide an objective quality control of the data, followed by a manual check. None of the data should be discarded; however, the suspected "bad" data should be flagged.

e. Symbology

The workshop participants agreed that no changes in the symbology be introduced to operational surface charts until the depiction of these maps can be improved within current resources and the analyses functions transferred successfully to a workstation. Any changes to the symbology should only be done in an experimental mode, side by side with the operational version utilizing the workstation.

8. Summary and remaining issues

The Surface Analysis Workshop provided a much-needed forum on an important meteorological product that historically has been a critical chart for forecasting and archiving purposes. The workshop enabled the participants to assess what's involved in preparing surface charts in an efficient manner without sacrificing a uniformly high quality. The workshop also provided an opportunity for synoptic meteorologists outside of NMC to gain a better appreciation of the stress imposed on surface analysts by operational time constraints. The workshop enabled skilled meteorologists from a large spectrum of the meteorological community to influence the future plans for operational surface analyses and to help chart the course for the transfer of this function to a workstation environment.

As reported in the document, the workshop succeeded in reminding those in attendance of the general importance of surface analyses as a primary meteorological chart that can provide an important view of the "workings of the atmosphere," if done correctly. The participants also contributed to the summary of the requirements for operational surface maps, and provided an important framework, conceptual design, and associated data requirements for the efficient production of operational surface maps in a computer-based workstation environment. In three days, we were able to utilize the knowledge based on

Objective Hourly Maps	0	1	2	3	4	5	6	7	8	9	10	11	12
3-H North Amer. Maps (subjectively modified)	•			•			•			•			•
6-H Northern Hemisphere Maps (subjectively modified)	•						•						•
Once-Per-Day Daily Weather Map (subjectively modified)	•												

FIG. 5. Conceptual design of data flow for NMC surface analysis on an interactive workstation. The objective hourly analysis could be provided by observations, data assimilation systems, and/or model forecasts.

an incredible amount of synoptic experience to reinvigorate current operations and plan the future for the centralized production of surface analyses that should remain as an important source of information for research, government, military, private weather offices, and historical archives.

Several important steps have been taken since the workshop was held. First, a "surface analysis team" consisting of highly motivated individuals was created within MOD on 6 May 1991, bringing this function under one senior manager who reviews the product on a daily basis. In addition, an intern program was also instituted on 6 May 1991 that is based on a structured two-year training effort. The intern training at NMC/MOD includes basic surface analysis principles and the application of various workstations to the generation of weather charts, starting with the production of the Daily Weather Map series on the Intergraph workstations. MOD has also produced an internal surface analysis training manual and the first draft of a requirements document, which represents an important step in transferring the operational surface analysis from a grease-pencil/acetate mode to a workstation environment. Additionally, steps were taken by NMC's Automation Division to improve the plotting for ship reports and buoys for the current NH charts.

Many issues were not resolved during the workshop. There was a general recognition of the importance of conceptual models and the need to modify those based on Norwegian concepts produced early in this century. Nevertheless, there was little agreement among the synopticians at the workshop as to which modifications are acceptable. There was also a basic disagreement within the working groups about symbology, with some wanting fewer lines on the maps (for example, no fronts), while others want more boundaries to represent mesoscale features (based perhaps on the definitions provided by Young and Fritsch 1989). The NWS Science Service division chiefs from the various regions were unanimous in their opinion that no basic changes in symbology should be introduced until the current suite of products is improved and transferred to workstations without any degradation in services, a position with which NMC agrees.

Finally, training issues were discussed. Experienced forecasters and management personnel at NMC perceive a decrease in the analysis skills of university students entering the NWS, and that a major effort is needed to rectify this problem. Based on comments at the workshop, it is not likely that the universities will be in a position to rectify this situation and that the NWS will have to deal with training issues associated with surface analyses to ensure the future quality of both its analysis products and associated forecasts.

Acknowledgments. We wish to thank all of the workshop participants for their willingness to attend and assist NMC in reviewing the situation surrounding the surface analysis function and identifying possible solutions. We feel that the success of the workshop was a direct function of the enthusiastic participation offered by each of those attending. We also thank Robert Derouin, Gerald Delaney, Jeanette Rolen, and Linda Burroughs for their efforts in handling the logistical support before and during the workshop, and to Linda Burroughs for typing the manuscript.

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Summary of the American Meteorological Society Tenth Conference on Biometeorology and Aerobiology, 10–13 September 1991, Salt Lake City, Utah

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Kyaw Tha Paw U,[3] Roni Avissar,[4] Richard H. Grant,[5] and G. LeRoy Hahn[6]

1. Introduction

This conference was arranged by the Committee on Biometeorology and Aerobiology of the American Meteorological Society (AMS). The program committee consisted of John K. Westbrook and Dennis M. Driscoll (conference co-chairmen), G. LeRoy Hahn, Roger H. Shaw and Kyaw Tha Paw U, Richard H. Grant, Cynthia Rosenzweig, National Aeronautics and Space Administration/GISS, Roni Avissar, Rachel Pinker, (University of Maryland), and Michael D. McCorcle (Science Applications, Intl.). The conference program has been published (*Bull. Amer. Meteor. Soc.,* **72,** 716–724).

The conference was convened concurrently with, and complemented, the 20th Conference on Agricultural and Forest Meteorology, Seventh Conference on Applied Climatology, and the Special Session on Hydrometeorology. The conference served as a unique forum for the presentation of biometeorological and aerobiological research that typically attracts minor interest from participants at other AMS conferences. A concerted effort was made to solicit papers from scientists who are implicitly involved in biometeorological and aerobiological research, but who may not be allied with these disciplines. A successful outcome of this effort was the sponsoring of the annual meeting of the North–Central Regional Committee NCR-148 "Long-Distance Dispersal of Insects and Other Biotic Agents." NCR-148 hosted an open discussion on a proposed Alliance for Aerobiological Research (AFAR), and several members of NCR-148 presented conference papers.

Seven sessions were scheduled. There were sessions on Human Biometeorology; Atmospheric Physics and Aerobiology; Aerobiology of Pollens, Spores, and Biological Aerosols; Land–Atmosphere Interactions at Regional and Global Scales (held jointly with the Special Session on Hydrometeorology); Urban Climate and Biometeorology; Insect Biometeorology; and Animal Biometeorology. Forty-six papers were presented, including an invited presentation by Donald E. Aylor at the session on Atmospheric Physics and Aerobiology. Preprints of the conference have been published by AMS.

2. Session summaries

a. Human Biometeorology (Driscoll, chairperson)

In the session on human biometeorology, Driscoll suggested that belief in weather influences, which is much more pervasive on the other side of the Atlantic than ours, may be specious because of 1) the difficulty of proving a negative; 2) the way people are inclined to use weather as a scapegoat; 3) of the psychosomatic component to illness; and 4) often, in scientific inquiry, we find something if we look for it, even though it's not there. A parallel with the paradox of Schroedinger's cat—an example from quantum mechanics—was drawn. A spirited discussion of reasons for such divergent views on weather influences followed. Abdel Maarouf discussed health effects related to an air pollution episode in Toronto. An expected maximum in hospital admissions there was not observed at a time when the air pollution index reached a seven-year high. It was suggested that hospitalization of children two days prior to this episode, in response to a relatively minor pollution episode, may have reduced the number of the potentially sick for the next few days. Tan found that episodes of high temperature during

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the summer and prolonged periods of abnormally low temperature in the winter were related to increased human mortality. Kacergiene et al. gave the results of empirical studies that specify the ecological factors in forming the adaptive-compensatory processes in children and pregnant women. By examining correlation coefficients between intracellular enzymes in blood leucocytes and maximum concentrations of chemical pollutants, she showed a link to the intensity of the general adaptive syndrome, the decrease of the antimicrobial cellular processes, and the labilization or destruction of cellular structures.

b. Atmospheric Physics and Aerobiology (Shaw, chairperson)

In an invited review paper, Aylor focused on what he believed to be the central problem in aerobiology: quantification of the aerial dispersal of microorganisms. He considered both active and passive liberation of spores from leaf surfaces and emphasized the importance of turbulence to the latter. Intermittent wind gusts also play a role in the escape of spores from the canopy and are important in shaping disease gradients.

Paw U presented a further analysis of a process he proposed a decade earlier concerning rebound and reentrainment of particles larger than 10 microns in diameter. He presented evidence to support his hypothesis that the combined process of "rebound–reentrainment" results in a decrease in net deposition over that when rebound and reentrainment are considered separately.

Lin et al. discussed heavy-element deposition from air pollution to forests and described the analysis of foliage samples from trees at different sites in eastern Canada. A number of analysis techniques were evaluated. The authors compared rural and urban sites and considered the influence of elevation, but stressed that a much more extensive database is needed to arrive at more definite conclusions.

Malek et al. reported a field experiment in which they used the Bowen ratio–energy balance methods to estimate evapotranspiration (ET), from which crop resistance was calculated with the Penman–Monteith equation. Canopy resistances were believed to depend on light intensity, leaf water potential, crop height, and wind speed.

c. Aerobiology of Pollens, Spores and Biological Aerosols (Paw U, chairperson)

In this session, several interesting papers described ecological and medical aspects of aerobiology. In addition, a paper concerning microclimatic gas fluxes in chambers was included as a result of administrative procedures in coordination with other sessions.

Raddatz et al. forwarded the radical hypothesis that influenza virus aerosols may be transported over intercontinental distances through the atmosphere, causing disease outbreaks. Basic trajectory analysis for upper-level winds showed this possibility for east–west movement. Levetin et al. raised the possibility that conifer pollen could be significant aeroallergens based on airborne concentration data and biochemical similarities with known allergens. Comtois discussed the viability of pollen as a function of the altitude of ecosystems, and the relationship between this and fog occurrence. He found some indication that there was a discontinuity of viability at the mean cloud base, supporting the hypothesis of pollutant, humidity, and fog/cloud interaction with viability. DiGiovanni noted that pollen transport respresented a serious problem when attempting to maintain genetic lines in orchards developed for seed production. He described experimental and modeling efforts to determine methods that decrease such genetic contamination in anemophilous species.

Finally, Jetten discussed the important issue regarding the similarity of open top chambers to unenclosed field conditions. Experiments carried out in Wageningen were compared to an energy and mass balance model. The study showed that modification of the plant microclimate led to biometeorological interactions implying greater, equal, or lesser uptakes of gaseous pollutants by plants within the chambers when compared to field plants.

d. Land-Atmosphere Interactions at Regional and Global Scales (Rosenzweig, Avissar, and Pinker, cochairpersons)

This session was aimed at evaluating parameterizations of land–atmosphere interactions that have been introduced for use in regional and global atmospheric models, and determining their impacts on hydrologic cycle, weather, and climate. Several questions relevant to this problem were posed, e.g., how well do these parameterizations represent the real world land surface? Do they provide accurate and appropriate forcing for the atmospheric processes? How should small-scale processes be represented at larger scales in such models? In order to predict land-surface energy fluxes accurately, do we need to include dynamics of various atmospheric components such as CO_2? Which are the land-surface characteristics that play a major role in land–atmosphere interactions? Can they be evaluated by remote sensors? At which scale?

Gutman summarized available datasets and potential applications of AVHRR satellite observations in support of numerical climate models. Other aspects of the use of remote sensing to provide land-surface characteristics and test land-surface parameterizations were presented by Ben Mehrez et al. and Glassy. Ben Mehrez et al. claimed that plant stomatal resistance, one of the most important and difficult parameters to estimate for energy and water budget at the land surface, could be estimated from thermal infrared and microwave remote sensors.

Two types of land-surface parameterizations were discussed in this session. The now-considered "classical" parameterizations are based on the "big leaf" approach, which assumes horizontal homogeneity at the grid scale of the numerical model, and requires representative land-surface characteristics at this scale. This approach has been adopted and was discussed by Lee et al. for a mesoscale model, and by Xue et al., Rosenzweig et al., and Webb et al. for general circulation models (GCMs). Recently, parameterizations based on statistical–dynamical approach have been suggested. With this approach, land-surface characteristics at the grid scale of the model are represented by probability density functions that account for the subgrid-scale horizontal heterogeneity found in the real world. This approach was presented and discussed by Famiglietti et al. and Avissar. The land-surface parameterization implemented in a GCM by Koster et al. accounts also for subgrid-scale heterogeneity. The heterogeneity of the landscape in their study is represented by a mosaic of tiles, where each tile is parameterized as a "big leaf."

Schuepp discussed the importance of land-surface patchiness due to horizontal heterogeneity of drying, based on electrochemical simulations. His preliminary results emphasized the predominance of vertical over lateral components of transfer, under the experimental conditions. Paegle et al. discussed the importance of a correct parameterization of physical processes such as radiation and latent heating, as compared to the initialization and assimilation of observations for the simulation of low-level jet around the Andes.

Finally, observational evidences of land–atmosphere feedbacks were presented by Lare et al. (Sahelian drought), and by Kunkel et al. (U.S. drought, 1988).

e. Urban Climate and Biometeorology (Grant, chairperson)

Several of the papers described the impacts of vegetation on the urban environment at various scales. The variation in intensity of an urban heat island in three arid urban environments in Mexico was presented by Jauregui. His results indicate that vegetation surrounding and in an urban area reduce the heat island. The differences between suburban and rural areas in hot arid environments were studied by Grimmond, with results showing that the differences in energy fluxes between areas are greater than commonly found in temperate environments. Extensive use of irrigation water in the arid environments was the basis for a water-use study by McPherson et al. Their results show that vegetation used in the arid environments should be xeric-adapted. The energy balance of walls of residential buildings under varying xeric and lush landscaping schemes were modeled, measured, and described by Simpson. Results showed that the presence of transpiring vegetation greatly reduced the heating of walls. The impact of vegetative transpiration on the internal boundary layer overlying suburban areas in temperate regions was discussed by Grant, with results showing the greater tendency for inversions to form over suburban areas with more tree cover. Wind breaks were shown by Heisler to reduce

Turbulence and variable microclimate conditions were discussed relative to variable pollen distribution in the Montreal urban area by Prenot et al. Understanding the influence of vegetation type, distribution, and amount on the urban climate is moving forward. Understanding the basic effects of vegetation on the urban climate will greatly increase our ability to transfer knowledge between climatic zones.

energy use the greatest when used in the winter in the northern United States. Turbulence and variable microclimate conditions were discussed relative to variable pollen distribution in the Montreal urban area by Prenot et al. Understanding the influence of vegetation type, distribution, and amount on the urban climate is moving forward. Understanding the basic effects of vegetation on the urban climate will greatly increase our ability to transfer knowledge between climatic zones.

f. Insect Biometeorology (Westbrook and McCorcle, co-chairpersons)

The session on insect biometeorology focused on a unifying theme of insect migration, owing principally to the participation of members of NCR-148. Isard et al. opened the session with a discussion of AFAR. The AFAR concept was described as an infrastructure by which research of the atmospheric dispersion of biota could be supported and coordinated. Presentations of original research were categorized into two categories: day-flying insects and noctuid agronomic pests.

Participants realized remarkable similarities in the significance and timing of synoptic-scale circulation on the migration of various insects in the central United States.

Carlson et al. documented atmospheric trajectories from the south-central U.S. and synoptic weather conditions en route that led to heavy infestations of the day-flying potato leafhopper in Michigan. Greenstone revealed the vertical characteristics of the taxonomic distribution of beneficials (arthropod enemies) based on aircraft netting of day-flying insects.

Initiating presentations on noctuid pests, Johnson et al. discussed a paradigm for the migration of the velvetbean caterpillar across the Gulf of Mexico from southern Florida to coastal Louisiana. Fast et al. presented two forms for the prediction of long-distance dispersal of black cutworm from the south-central United States. Westbrook et al. summarized unique meteorological and entomological radar observations in the nocturnal planetary boundary layer and their application in insect transport and dispersion models. Beerwinkle et al. presented temporal series of entomological radar profiles of noctuid flight and discussed their relationship with temperature inversions and low-level jets. Lingren et al. presented entomological observations of corn earworm flight behavior from emergence to ascent into the nocturnal planetary boundary layer.

g. Animal Biometeorology (Hahn, chairperson)

Two papers discussed research of livestock animals, and one presented research of fauna. Sagar et al. showed that the coat conductance of heat from deer in the high turbulence regime of a second growth Douglas fir stand was enhanced by 10%–20% over that in a wind tunnel. Hahn et al. suggested that fractal analysis supports the establishment of thresholds for adverse effects on animal performance, health and well-being, and bioenergetic and thermoregulatory control modeling. Such results are useful in improving management criteria and possibly for the selection of animals adaptable to adverse environments. Shebaita and Fekry introduced a new approach for assessing acclimatization in cattle, based on changes in blood electrolyte parameters during exposure to hot climates. ●