DENVER ARTCC EVALUATION OF PROFS MESOSCALE WEATHER PRODUCTS

John W. Hinkelman
NCAR/NOAA/PROFS

The Denver Air Traffic Control Center has had a Prototype Regional Observation and Forecast System (PROFS) display system since the Spring of 1982. At the request of the Chief of the Denver Center, I will give an updated presentation of the evaluation the Center has made of the PROFS products. A full PROFS workstation capability was installed at the Denver Center in June 1984, and information concerning this can also be obtained through PROFS.

A PROFS display capability was requested by the Denver Center through the FAA Regional Office in 1981. The FAA was concerned with the safety and economic impact of adverse weather in the Denver air traffic control (ATC) environment (Figure 1). Stapleton Airport is a particularly difficult terminal from a weather standpoint because it has a tendency during bad weather to adversely affect the Denver Center's operation, and this frequently affects transcontinental traffic as well. Also Stapleton is a big hub operation for three airlines.

There are four significant and typical weather situations. One that occurs everyday involves wind shifts which force runway changes, and occur quite frequently during heavy traffic hours (i.e., noon and the evening rush hour). Severe thunderstorms, severe mountain wave turbulence, and upslope storms are the other three. We have had three significant upslope cases since January 1, 1985, which severely disrupted operations in the Denver Center area. The FAA real operational requirement is for timely detection and prediction (0-2 hours for safety, and 0-6 hours for economic reasons).

Figure 2 shows a hard copy printout of display data provided to the Denver Center since the Spring of 1982 when the first system was installed. The circle is the TRACON area, the isolines are weather radar reflectivity data (20,40,60 dBZ), with Stapleton in the center. On this particular day, there was a level-6 thunderstorm right over the outer marker. We are displaying flow lines, and the Limon Radar is shown along with mesonet temperatures, humidity, and wind information.

During the 30 months of the initial display evaluation, the system operated 24 hours a day, seven days a week (Figure 3). There were 150 significant cases reviewed. Of those 150 cases, 38 were analyzed in detail, 25 of which were reported on to the FAA. Of the 38 representative events analyzed, 14 were thunderstorms, 12 were wind shear/wind shifts, 7 were upslope cases, and 5 were combined thunderstorm/upslope cases. There was a positive impact on operations in 33 of the cases based on the

Adverse Weather Seriously Impacts:

- Both safety and cost operations in Denver ARTCC area
- Disrupts Denver Stapleton Airport operations
- Frequently affects transcontinental traffic flow

Four Significant Weather Situations:

- Approach area wind shear/abrupt runway wind shifts
- Severe thunderstorms
- Upslope storms—widespread low visibility/precipitation

Timely (0-6 hour) Detection and Prediction Can:

- Improve safety
- Decrease delay costs

Figure 1. Operational requirement.

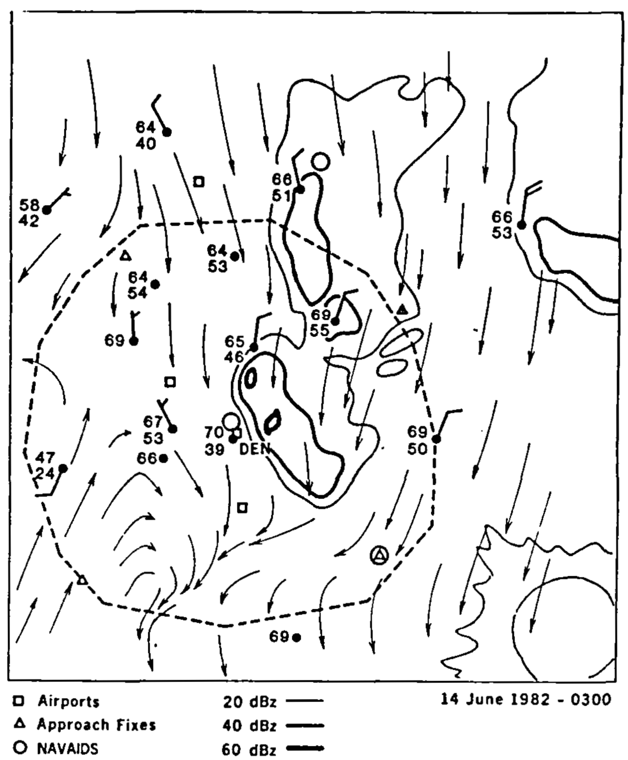

Figure 2. Typical PROFS mesoscale graphic product covering Denver Stapleton area. Limon radar is in circle at bottom right.

- 30 Months—Daily use supporting Stapleton traffic operations
- Over 150 significant cases analyzed
- 38 serious events chosen for analysis strong operational impact
- Representative Events
  - 14 Thunderstorms
  - 12 Wind Shear/Wind Shifts
  - 7 Upslopes
  - 5 Combined Thunderstorm/Upslope
- Positive Impact—33 Cases
  - 12 Thunderstorms
  - 5 Terminal Wind Shears
  - 6 Wind Shifts
  - 6 Upslopes
  - 4 Combined

Figure 3. Real-time weather impact.

- Conventional Radar Cell Tracking very valuable in predicting arrival gate and terminal operations restrictions.
- Automated Surface Observations (mesonet) critical for low ceiling and visibility onset/cessation.
- Automated Radar and Surface Data combines/overlays extremely valuable determining cell development and tracking.
- Profiler Winds effective for flight path prediction, forecasting upslope, thunderstorm cell tracks.
- Doppler Radar needed to better forecast airport wind shift timing and locate low-level wind shear areas.
- ATC confidence level increases with timely accurate tailored information.

Figure 4. Product utility.

Case file sequence begins at 17:40:58 (1141L). The synoptic situation had been analyzed early in the period and a strong frontal passage was inevitable. Timing of the event remained questionable due to sparse conventional data north and east of the Denver Stapleton Airport in northeastern Colorado, western Nebraska and southern Wyoming. The Denver ARTCC meteorologist began surveilling the northern portions of the mesonet display during early morning hours and first detected a FROPA at about 1730Z. This information was used to provide a forecast to Denver tower and ARTCC traffic management that the front should reach Stapleton between 2030Z and 2100Z with resultant wind shift and possible reduced visibility due to blowing dust. No precipitation was forecast for the frontal passage due to low moisture availability. At 1935Z the CWSU meteorologist issued a center weather advisory (see below) based on 180° wind shear at 33 kn between LGM and LVE on the mesonet per FROPA at Denver at 2030Z.

Denver ARTCC and Denver tower personnel began to formulate traffic flow restrictions and runway configuration plans immediately and traffic speed reductions as well as expanded quota flow from CF2 after the 2000Z hour to avoid sector saturation and excessive airborne delays.

The front passed Denver at 2027Z, within 3 minutes of forecast with visibility reduction to 1 nm. Some airborne delays were experienced for a period of time due to single runway operations but traffic flow was maintained smoothly throughout and system perturbations were effectively minimized.

The meteorologist knew it would be a strong frontal passage from synoptic data. Where mesonet really helped was with timing, and also the amount of shear.

Apparently the front was first detected in NRN portions of mesonet around 1730Z and an initial FROPA estimate for DEN was made.

At 1930Z, what really prompted the CWSU to issue the CWA was the 1915Z mesonet - - notice the 180° shear at 33 kn between LGM and LVE.

Front passed Den at 2027Z, 3 minutes before fcstd in CWA.

W2 CWA...1935Z MON SEP 19 1983...AN EXTREMELY STRONG FRONTAL BOUNDARY WITH WIND SHEAR TO 70-80 kn CURRENTLY MOVG THRU NRN PTNS DEN TRACON AREA...WINDS WITH FRONTAL PASSAGE SHIFT TO N-NE AT 30-40 kn ...FRONT EXPCD BY DEN STAPLETON AT 2030Z...CAUTION FOR EXTRM LO LVL TURBC AND BLWG DUST. ZDV CWSU 191935Z

Figure 5. Case Description from Denver Stapleton, September 19, 1983. (Transcribed from computer printout)

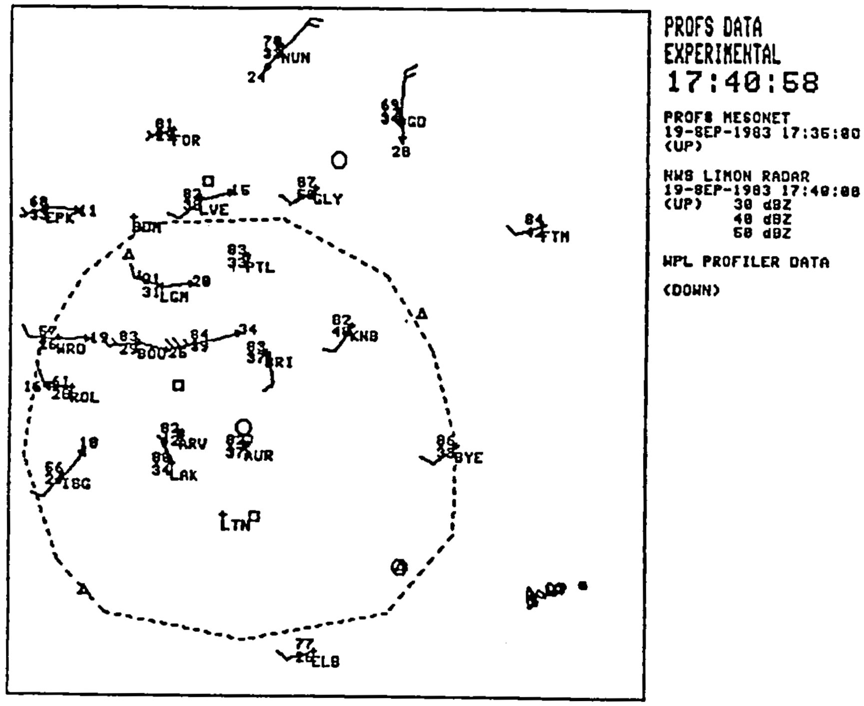

Figure 6. PROFS Experimental Data Display, September 19, 1983, at 17:40:58Z.

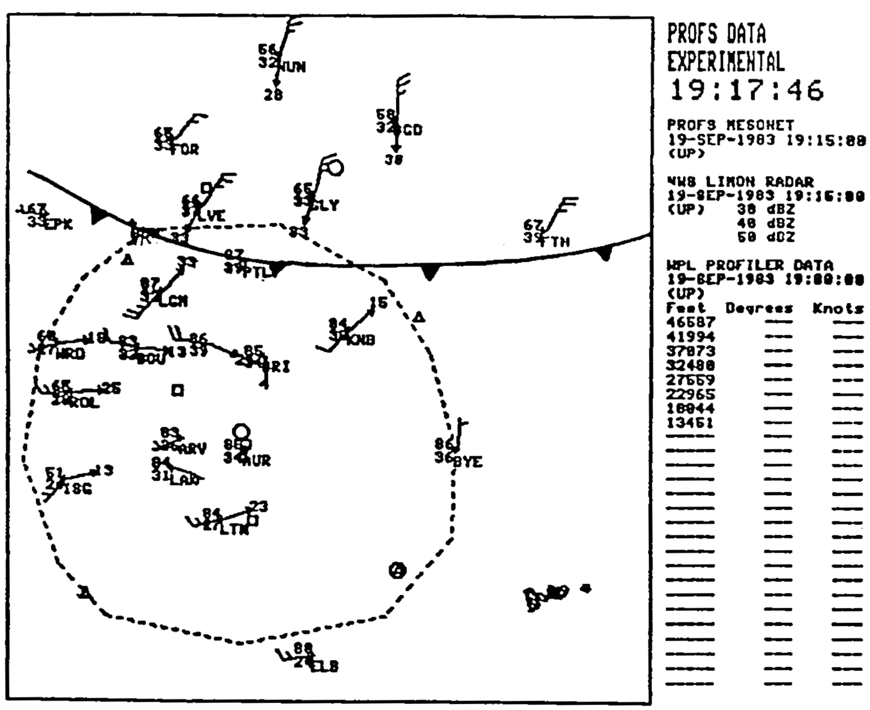

Figure 7. PROFS Experimental Data Display, September 19, 1983, at 19:17:46Z.

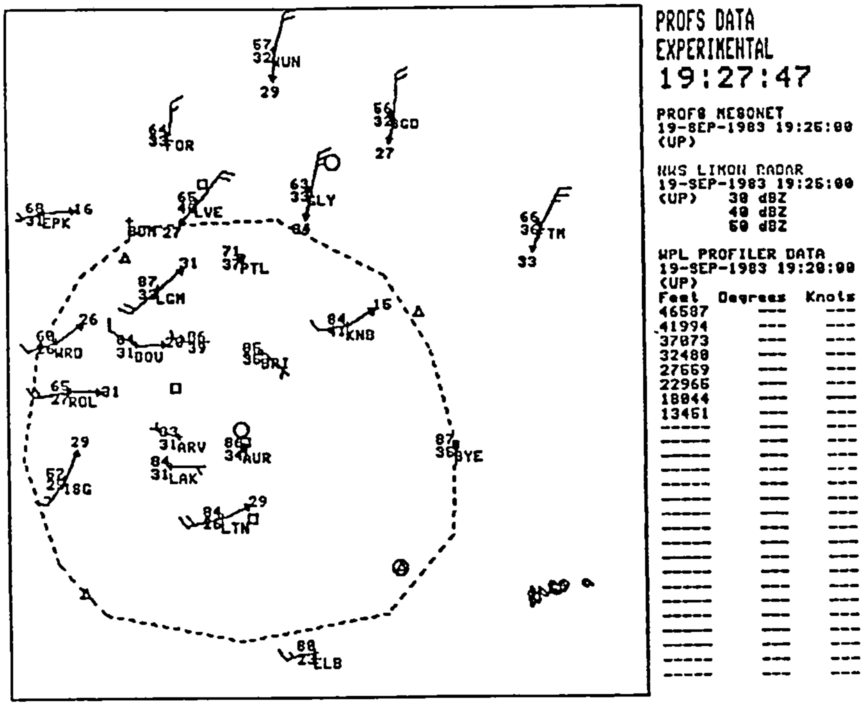

Figure 8. PROFS Experimental Data Display, September 19, 1983, at 19:27:47Z.

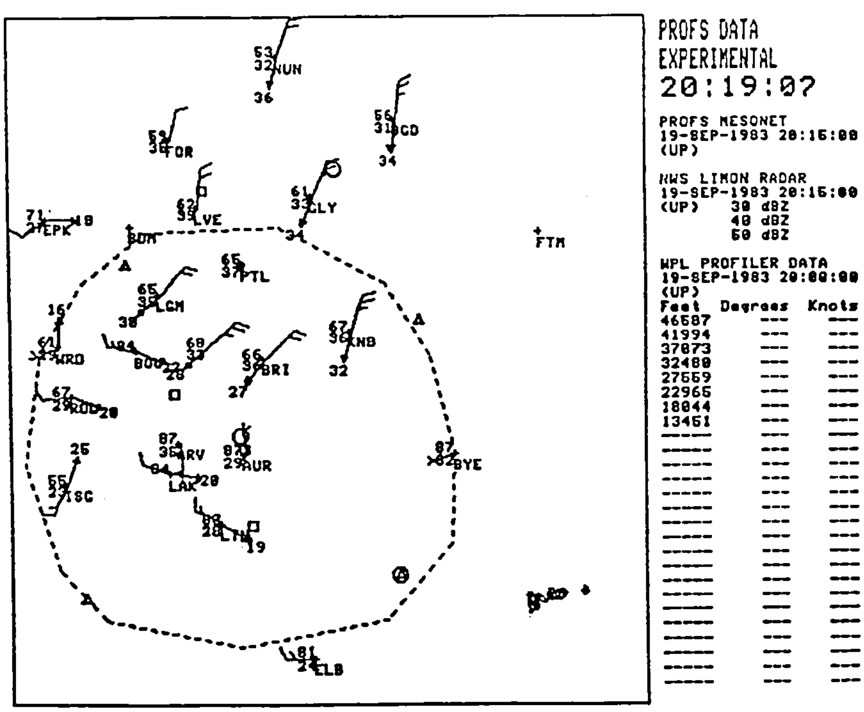

Figure 9. PROFS Experimental Data Display, September 19, 1983, at 20:19:07Z.

analyses performed by the CWSU and ATC people at the center.

From a product utility standpoint (Figure 4), conventional radar cell tracking was extremely valuable for predicting arrival gate and terminal operations restrictions, particularly during rush hours. Automated surface observations (mesonet) were critical for low ceiling and visibility onset and cessation. The automated radar and surface data combinations were the most valuable for predicting cell development and track information. Profiler winds were quite effective for flight path prediction, input to the ATC 90/20 computer forecasting upslope conditions, and thunderstorm cell tracking. The center would like to have Doppler radar information for wind shear forecasting, etc. We do not plan to provide that capability for several years. The ATC Weather Information confidence level has increased steadily with the timely PROFS information.

Figure 5 is a case description for September 19, 1983, and Figures 6 - 9 are actual hard copies of the information used in the control room. On each display it is noted that the data are PROFS experimental data. What I would like to show you in these figures is how accurately we were able to predict wind shifts which caused runway changes. Figure 6 shows that at approximately 17:40 Z, which is about 11:40 a.m., a front was moving down from the north. You will note that although the Limon radar was operative, no echoes were showing from the radar. Within one hour and 15 minutes the frontal system moved down into and across the TRACON area. At 19:35 Z, the frontal passage was forecast for Stapleton at 20:30 Z (Figure 7). Figure 8 shows that at 19:27, the system is continuing to move; and at 20:19, Figure 9 shows that there has not been a shift at Stapleton, but there has been a wind shift just to the north at Brighton. This was predicted roughly 55 minutes in advance. The CWSU has been forecasting this type of wind shift consistently for the past two years.

We are currently in the Denver Center Phase II Program (Figure 10), which involves a full PROFS work station providing radar, mesonet, satellite and AFOS products. We provide time series analyses of each of the mesonet stations, and are depicting all the profiler stations' data. We actually have four profiler stations in operation now, and the network is being reconfigured with additional stations. We are not providing Doppler radar coverage now, as mentioned earlier; however, we may provide some output information from CP-2 this summer. We are providing automated PIREP information to the center. In summary, we have been focusing on display information for the CWSU work station, output products to the ATC system, and developing functional specifications for the FAA CWSU work station of the future.

Question from the floor: Mike Tomlinson, NWS

Full Meteorological Work Station

- Interactive displays
- Touch-screen menus
- High resolution color
- Overlaying, looping, zooming

Expanded Data Sets

- Doppler Radar coverage
- 5-station profiler network
- Automated PIREPs
- AFOS product overlay capability

Focusing On:

- Output products to ATC system
- Work station display
- Functional specifications

Figure 10. Current Phase II Program.

Everything you have shown seems to concentrate almost exclusively in the Denver Stapleton area, and the Denver ARTCC area is considerably larger than that. Do you have similar types of capabilities to cover the rest of the area; and, if not, what kind of impact is this concentration of that one terminal having on the services provided for the remainder of the Denver ARTCC area?

Response: Jack Hinkelman

The Denver Center area may be unique because Stapleton is the primary throttling feature in the Denver Center area. It is the big terminal. Of course, there are Colorado Springs, Cheyenne, Pueblo, Grand Junction and other terminals; but Stapleton is the sixth or seventh most congested airport in the world. It is about the fifth in the U. S., and is a big problem area. They are normally operating at approximately 80-90 aircraft per hour almost continuously from 7:00 a.m. to 8:00 p.m. They are always operating at maximum capacity. Whenever there is a weather problem at Stapleton, both the en route system and the terminal system in that area becomes very unstable, and may stay that way for about four to five hours even after the weather dissipates. Therefore, we have concentrated on the Stapleton area. Although I have not shown any cases, we have several where thunderstorm track is predicted over the arrival and departure gates. Also, we are able to predict thunderstorm tracks out over the en route area, particularly to the east. It is more difficult out over the west. Most of the thunderstorms form in the mountains.

We have intentionally, at their request, concentrated on the Stapleton operation. It very frequently affects transcontinental operations. There is also profiler data which covers the whole center area, and that has been put into the 90/20. When the forecast winds appear to have been in error, we have been able to insert real-time profiler data in the 90/20 and the ATC computers settle down. We do not have radar data that covers the entire center area, so we can work only with what we have.

Question from the floor: Doug Lundgren, AOPA

What do you see in a broader, national scale for the future of a PROFS-type effort, particularly the mesonet? We can place sensors around a particular airport; but how can we correlate this with more sensors nationwide?

Response: Jack Hinkelman

As you know, PROFS is an experimental prototype of the AWIPS-90 program, which is the NWS program for implementation in the 1990's. In fact, there are mesonetworks around almost all major metropolitan areas in the country. EPA and other groups all have mesonets. I think a good part of the state of Tennessee is covered by automated surface observations, like the Tennessee Valley Authority (TVA). There is almost a full mesoscale network covering the state of Tennessee. There are four or five groups and none are reporting into a central computer. I think Sandy MacDonald could verify this, but we believe there is extreme value in mesonetworks. We don't see any national program to implement mesonetworks around major cities or airports, but it certainly would not be a bad idea. Maybe it will come about.