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JUNE 1988

CENTRAL REGION TECHNICAL ATTACHMENT 88-25

FORECASTING FOG DISSIPATION THE OLD-FASHIONED WAY

Richard J. Naistat
National Weather Service Forecast Office
Minneapolis, Minnesota

1. Introduction

With the advent of GOES satellites, numerous studies were conducted illustrating the benefit of satellite imagery in forecasting the dissipation of radiation fog. Gurka (1978) demonstrated that radiation fog dissipates from the edges and is dependent on the areal extent of the fog. However, often the thermal contrast between fog and no fog is so small that the fog's areal extent cannot be truly determined until visible imagery is available. This leaves the midnight aviation forecaster, during the hours of darkness, in a quandary as to not only will fog form, but when will it dissipate?

Wingert (1966), who retired from the NWS/Minneapolis Forecast Office in 1974, had constructed visibility improvement tables for MSP. He did this by stratifying radiation fog occurrences at MSP (from 1952-1964) as to whether (1) the fog produced a partial obscuration (-X) with a clear sky above and had reduced visibility to 1/2 mile or less for one hour or more through sunrise, or (2) the fog produced a total obscuration (X) with a clear sky above (that had to be estimated in the days before weather satellites at WSFO MSP) and had reduced the visibility to 1/2 mile or less for one hour or more through sunrise. These fog cases were further subdivided by their month of occurrence. This technical attachment will demonstrate the applicability of this "old-fashioned" approach that was used in real-time in aviation forecasting, in Special Weather Statements, and in the MSP ELF (during a test period).

2. The -X Fog Case of January 17, 1988

At 0600Z on Monday, January 17, 1988, skies were clear across Minnesota. The pressure gradient was weak, and the temperature-dew point spreads were small and narrowing (see Fig. 1). Given that the skies would remain clear and the surface pressure gradient weak, just about any forecaster would have felt confident in forecasting fog to develop. Indeed the 09Z MSP FT (issued at 0830Z) did forecast fog (see Table 1).

As the fog became more noticeable (circa 10Z), a forecast was made that the fog would be of the -X rather than total X variety (this was based on the 00Z STC raob which suggested the moisture was restricted to the surface which is more conducive to -X type fog). Entering Wingert's (1966) Visibility Improvement Table (see Fig. 2), a forecast was made that the prevailing visibility

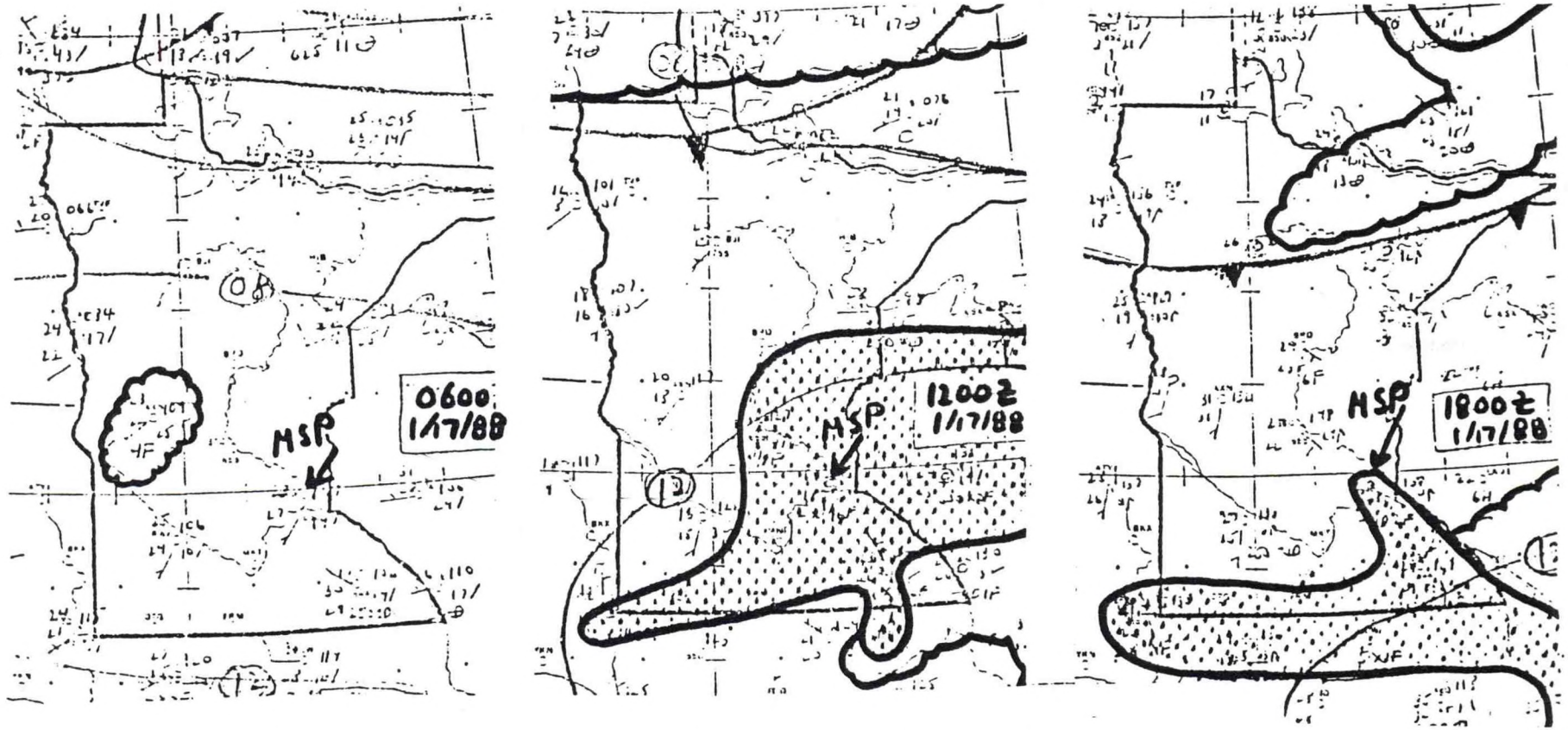

Fig 1. Surface analysis and weather depiction (with stippled areas indicating IFR conditions due to fog and scalloped areas depicting MVFR conditions due to fog) for 0600Z, January 17, 1988 (upper left), for 1200Z (upper center), and for 1800Z (upper right).

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Table 1. MSP FT's and hourly surface observations for MSP from 0550-1851Z on January 17, 1988.

MSP FT 170909 -X 250 -BKN 3F OCNL 1F.
16Z C250 BKN. 03Z VFR..

MSP FT AMD 1 171009 1026Z C1 X 1/4F
OCNL -X 1F. 17Z -X 3F OCNL -X 1F.
18Z C50 BKN. 03Z VFR..

MSP SA 0550Z CLR 7 28/27/2005

MSP SA 0650Z 0650Z CLR 6F 25/24/2005

MSP SA 0753Z CLR 5F 25/25/0000

MSP RS 0854Z CLR 5F 21/19/1906

MSP RS 0952Z -X 3/4F 20/18/0000

MSP SA 1052Z -X 1/2F 19/18/0000

MSP SA 1152Z -X 1/16F 19/18/0000

MSP SA 1250Z -X 1/16F 19/18/0000

MSP SA 1350Z -X M1 BKN 1/16F 19/18/0000

MSP RS 1452Z -X M2 BKN 1/2F 20/18/0000

MSP RS 1553Z W3 X 1/4F 20/19/0000

MSP SA 1653Z -X 250 -BKN 1F 23/23/0000

MSP SA 1753Z -X 250 -BKN 2F 25/25/1103

MSP SA 1851Z -X 250 -OVC 3F 30/28/0103

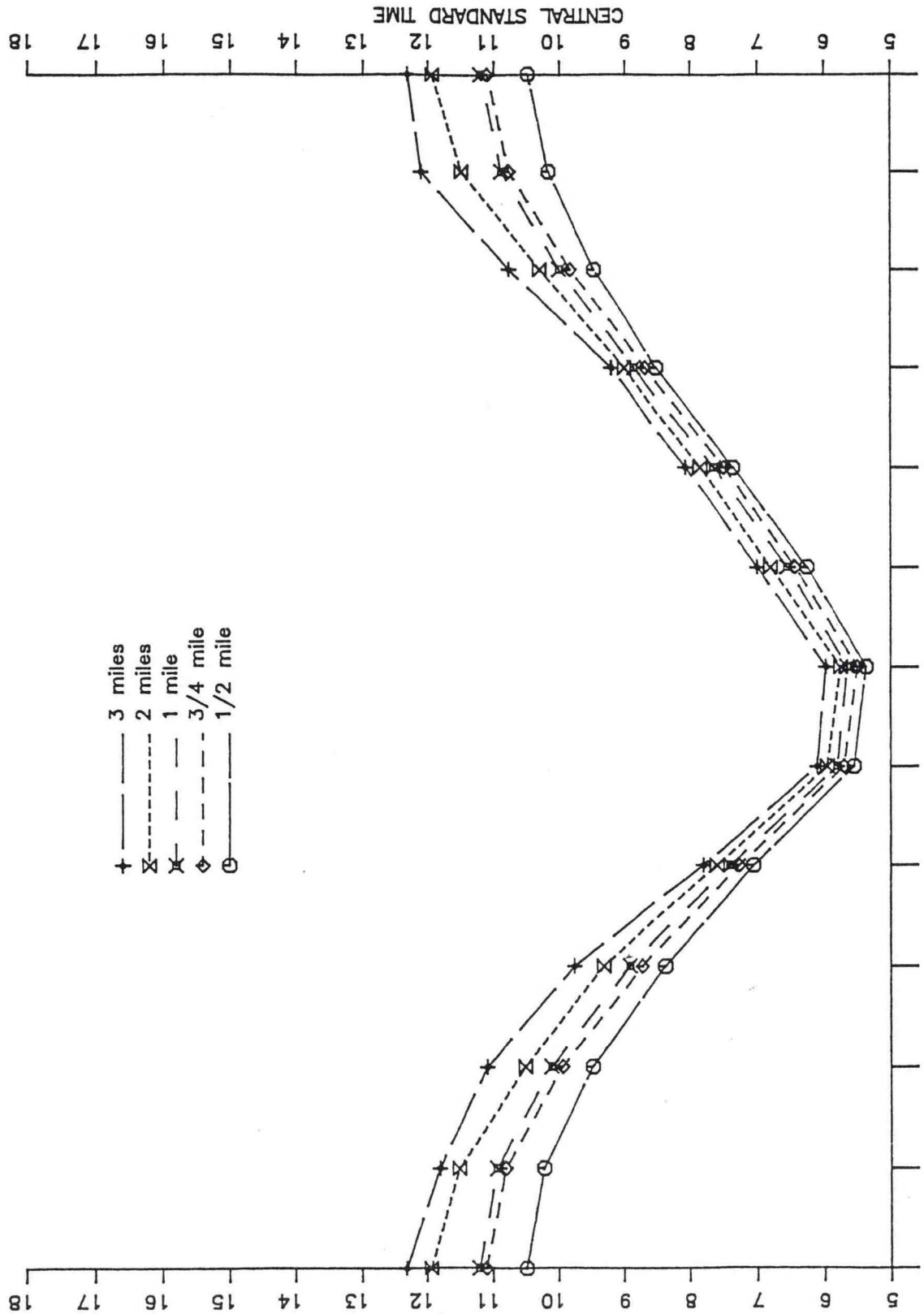

Fig. 2. Visibility improvement curves for -X ground fog with clear sky above when visibility has persisted below 1/2 mile for one or more hours through sunrise (for MSP). Month hatch marks are for the first of each month.

would not improve until above 1/2 mile at MSP until 1630Z. Fig. 5 represents the thin obscured improvement table for the 15th of each month. Not only was this forecast conveyed in the MSP amended FT issued at 1026Z, but it was also given verbally to the MSP Tower. Indeed, a check of the ensuing MSP observations showed that this did happen.

Reviewing Fig. 1, it can be seen that the fog area (IFR-stippled), expanded around 1200Z, then contracted significantly by 1800Z. Without the Visibility Improvement Table, the correct trend of fog dissipation would likely have been forecast, but the accurate timing would have been quite possibly lacking. It is interesting to note that in Fig. 1, the fog remained in extreme southern Minnesota. This can be explained, in part, from that area having been totally obscured rather than partially obscured by fog (which means a different table would have to be used).

3. The Totally Obscured Case of January 18, 1988

As luck would have it, the very next midnight shift presented an opportunity for using Wingert's Visibility Improvement Tables for fog that totally obscured the sky and reduced the visibility to less than 1/2 mile for one or more hours past sunrise.

At 0600Z on Tuesday, January 18, 1988 skies were clear in northern Minnesota but foggy in southern Minnesota. SWIS showed there were no higher clouds. Fig. 3 shows the surface pressure gradient was weak across Minnesota, although all the numerical models forecast the surface gradient to increase with time. Fortunately (for this study), the gradient would remain relatively weak at MSP. When it was time to issue the 09Z MSP FT, weather conditions were nearly zero-zero. The big forecast problem was: how fast would conditions improve. Once again Wingert's Visibility Improvement Table, this time for totally obscured sky, (see Fig. 4) was of immense value. Fig. 6 represents the obscured improvement table for the first of each month.

The 09Z MSP FT once again indicated that the prevailing visibility would not rise above 1/2 mile until 1630Z. This was also again verbally relayed to the MSP Tower for their operations. While the forecast for visibility to remain below three miles until 00Z was slightly pessimistic (see Table 2), it did fly in the face of experience (which usually has visibilities above three miles by 18Z). Also recall that FT's are extremely perishable: forecasting the visibility to stay below three miles for even 12 hours (09Z-21Z) is quite an accomplishment!

In this particular case, a Dense Fog Advisory had been issued. Its forecast duration, timing in Special Weather Statements, and the inclusion of "DENSE FOG THROUGH THIS MORNING" in the early morning MSP ELF all were possible because of this visibility improvement table.

What other strategy could have been employed? The MOS guidance, in both the case of January 17 and 18, 1988 was nowhere close to the mark. For example, let's compare the MSP FT issued at 0830Z on January 18, 1988 with the MOS FPC guidance for MSP. To be consistent with the MOS guidance only categories have been used with one being the worst and six the best. (The MSP FT ceiling was a guess/estimate) based on the forecaster's experience of what type of ceiling would correlate with a given visibility.

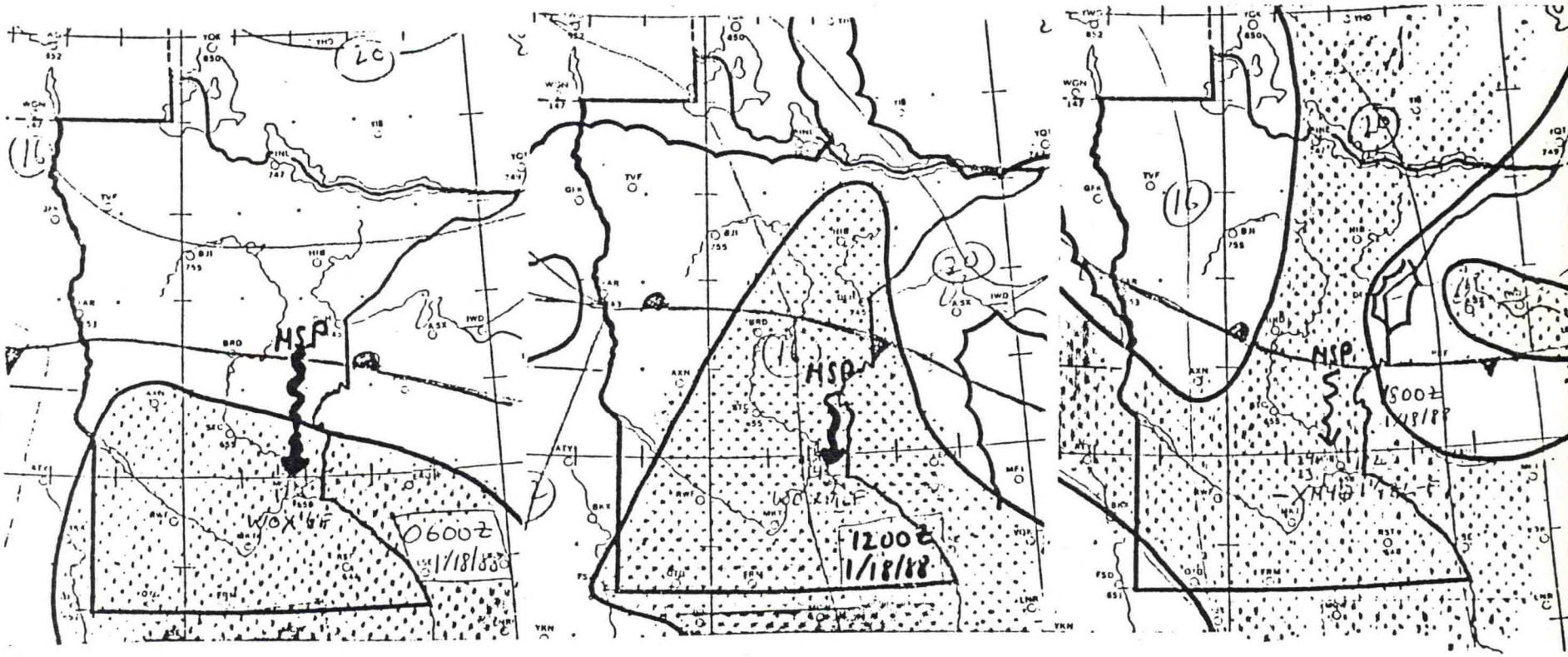

Fig. 3. Surface analysis and weather depiction (with stippled areas indicated IFR conditions due to fog and scalloped areas depicting MVFR conditions due to fog) for 0600Z, January 18, 1988 (upper left), for 1200Z (upper center), and for 1800Z (upper right).

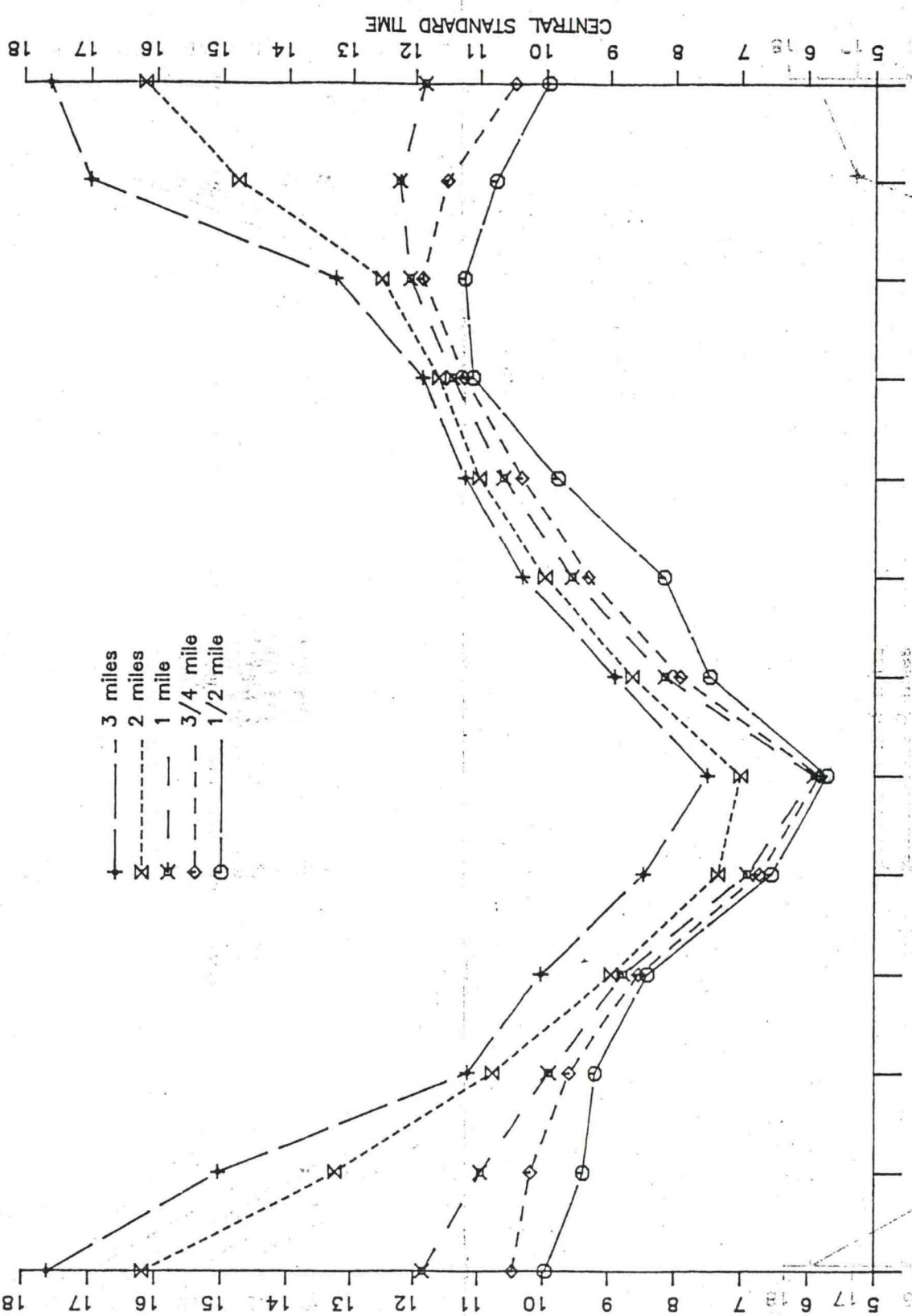

Fig. 4. Visibility improvement curves for MSP for solid ground fog with clear sky above when visibility has persisted below 1/2 mile for one hour or more through sunrise. Month hatch marks are for the 15th of each month.

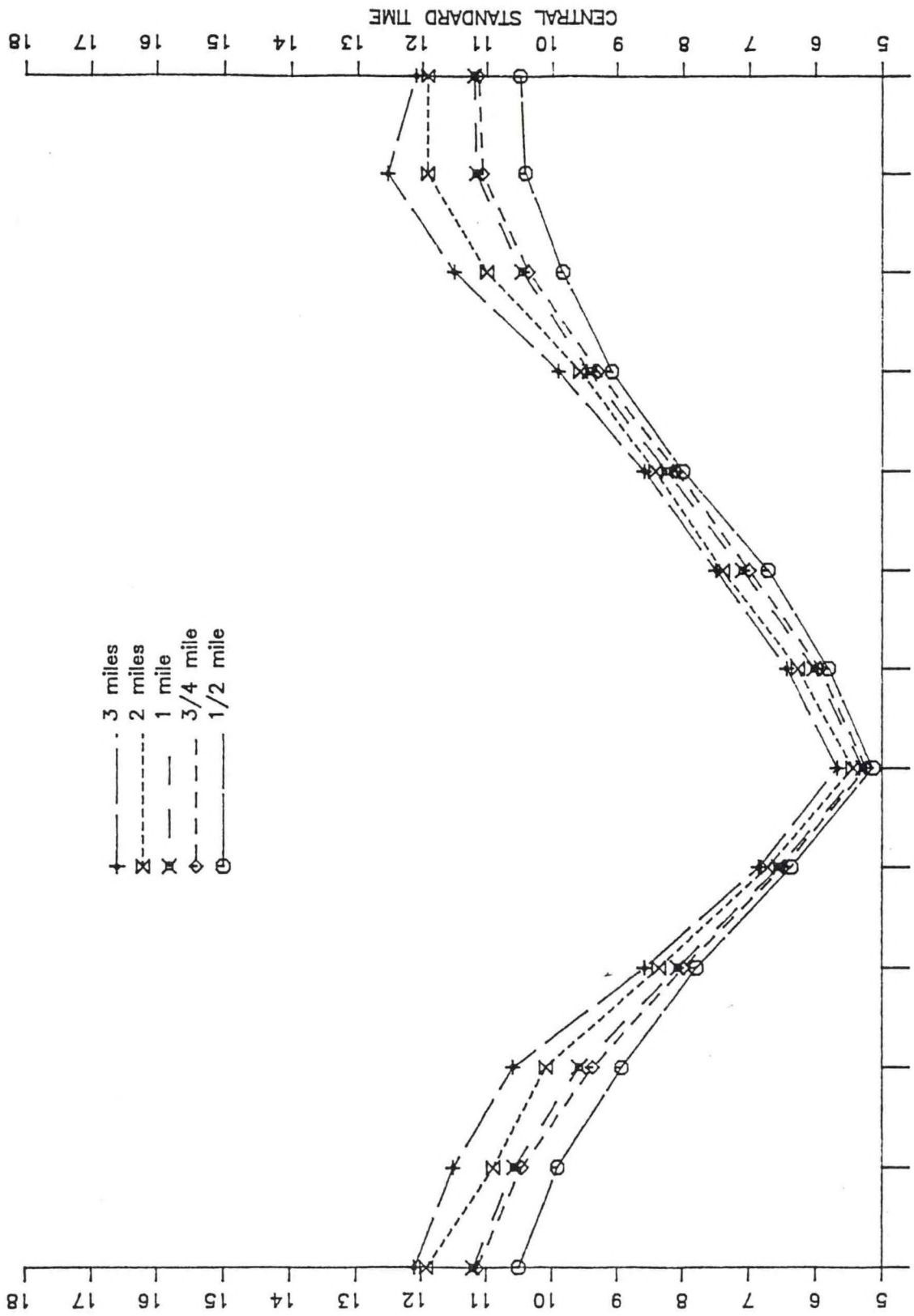

Fig. 5. Same as Fig. 2, except for the 15th of the month.

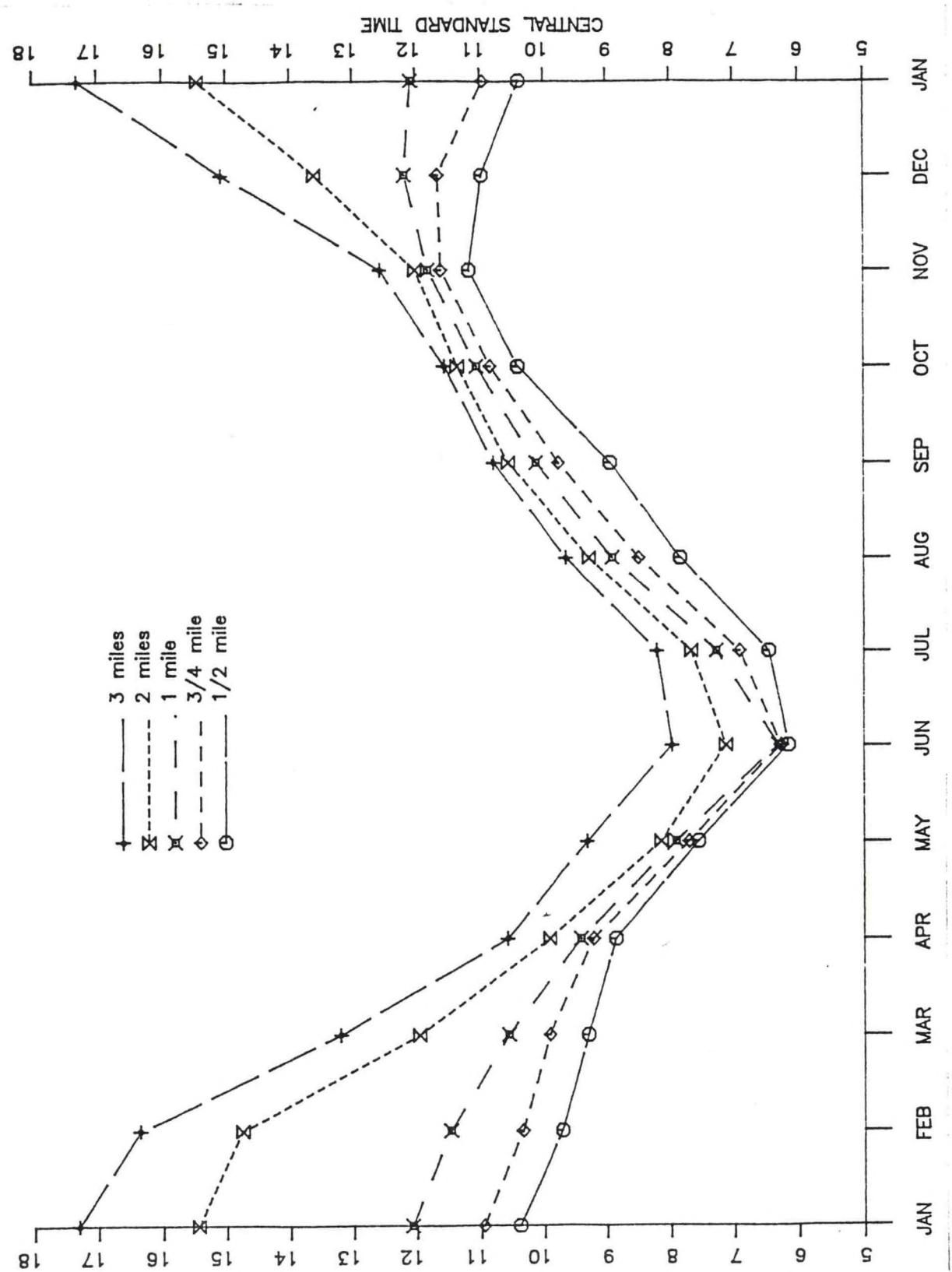

Fig. 6. Same as Fig. 4, except for the first of each month.

Table 2. MSP FT's and hourly surface observations for MSP from 0550-1850Z on January 18, 1988.

MSP FT 180909 C1 X 1/4F OCNL -X 1/2F. 16Z C2 X 1/2F OCNL -X 1F. 18Z C5 OVC 1F 1406 OCNL -X 2F. 00Z -X 3F 1406. 03Z IFR CIG F..

MSP FT AMD 1 181509 1514Z -X M4 OVC 3/4ZL-F OCNL 1F. 18Z C 5 OVC 1F 1406 OCNL -X 2F. 00Z -X 3F 1406. 03Z IFR CIG F..

MSP SA 0550Z W0 X 1/8F 18/17/0704

MSP SA 0650Z W0 X 1/16F 18/16/0000

MSP SA 0750Z W0 X 1/16F 17/15/0000

MSP RS 0850Z W0 X 1/16F 18/17/0000

MSP SA 0950Z W0 X 1/16F 19/17/0000

MSP SA 1050Z W0 X 1/16F 18/17/0000

MSP RS 1151Z W0 X 1/16ICF 16/14/1406

MSP RS 1251Z W0 X 1/16ICF 16/15/0504

MSP SA 1351Z W0 X 1/16F 18/17/0304

MSP RS 1453Z -X M3 BKN 8 OVC 3/4F 20/19/1105

MSP SA 1551Z -X M3 BKN 7 OVC 1ZL-F 21/19/1205

MSP RS 1651Z -X M4 OVC 1ZL-F 23/22/1207

MSP RS 1751Z -X M4 OVC 11/4ZL-F 24/23/1107

MSP RS 1850Z -X M4 OVC 11/4F 26/25/1204

	12Z	18Z
MOS CIG/VSBY	6/3	6/5
MSP FT CIG/VSBY	1/1	3/3
Observed CIG/VSBY	1/1	2/3

4. Summary

While these visibility improvement tables were developed solely for MSP (based on MSP observations) experience at MSP has shown that for radiation fog, the tables are a good first-guess to be used just about anywhere in Minnesota. Tables 3 and 4 list modifications that can be used in situations other than clear skies and light winds.

These visibility improvement figures and tables may be applicable to locations other than Minnesota as well. Either by using these charts elsewhere, or by motivating other forecasters to produce such tables, this type of "knowledge transfer" can provide helpful information to both the novice and experienced forecaster.

5. References

Gurka, J.J., 1978: The role of inward mixing in the dissipation of fog and Stratus., Mon. Wea. Rev., 106, 1633-1635.

Wingert, M., 1966: Visibility Improvement Tables for MSP. Unpublished Report, National Weather Service Forecast Office, Minneapolis, MN.

Table 3. Notes on adaptive increments for partially obscured (-X) ground fog with clear sky above when visibility has persisted below 1/2 mile for one or more hours through sunrise (for MSP).

1. In October and November for water droplet ground fog over unfrozen ground: for high broken clouds above, subtract 30 minutes from 1/2, 3/4, and one mile curves, and subtract 20 minutes from two and three mile curves.

2. In November for ice fog over frozen or snow covered ground: use 1/2 mile curve as is, add 30 minutes to 3/4 and one mile curves, and add 80 minutes to two and three mile curves.

3. -X ground fog curves are probably subject to larger errors than the solid ground fog curves due to the greater thickness variability in the former which may range from 1/10 to 9/10 obscuration.

4. In July and August for wind less than three knots add 25 minutes to 1/2, 3/4, and one mile curves and add 60 minutes to two and three mile curves.

5. Average improvement to 1/4 mile is 93 minutes after sunrise through October with a range from 39 minutes to 185 minutes. Broken to overcast clouds above makes improvement slower than average April through October, and faster than average November through March. Surface wind over six knots will give faster than average improvement through the year.

Table 4. Notes on adaptive increments for totally obscured (X) ground fog with clear sky above when visibility has persisted below 1/2 mile for one or more hours through sunrise (for MSP), except as noted below.

1. In January and December: for surface wind 0-3 knots, add 35 minutes to curves; for surface wind 4-10 knots, subtract 35 minutes from 1/2, 3/4, and one mile curves, for two and three mile curves use as is.

2. In March: for surface wind below seven knots, add 65 minutes to 1/2 and 3/4 mile curves and add 50 minutes to one, two, and three mile curves; for surface wind 7-12 knots subtract 30 minutes from curves.

3. In April: for surface wind 0-6 knots add 55 minutes to curves; for surface wind 7-10 knots use curves as is.

4. In late May: curves are for clear sky above and wind 3-6 knots.

5. In July: curves are for clear to high thin broken above and wind 3-8 knots.

6. In August: curves are for clear above and wind 0-5 knots.

7. In October: for surface wind 0-3 knots add 10 minutes to curves; for surface wind 4-8 knots subtract ten minutes from curves; for high scattered to broken above fog subtract 125 minutes from 1/2 and 3/4 mile curves, 60 minutes from one mile curve, 45 minutes from two mile curves, and zero from three mile curves.

8. In November: for surface wind 0-4 knots, add 35 minutes to curves; for surface wind 5-10 knots use curves as is; for high scattered to broken above fog and any wind subtract 90 minutes from 1/2, 3/4, and one mile curves; subtract 30 minutes from two mile curve, and use three mile curve as is.

9. Anytime of year: introduction of high overcast layer above fog almost immediately improves visibility.

10. Average improvement to 1/4 mile is 142 minutes after sunrise through the year with a range from 77 minutes to 189 minutes. Broken to overcast clouds above makes improvement slower than average April through October, and faster than average from November through March. Surface wind over six knots will give faster than average improvement through the year.