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Nowcasting Surface Meteorological Parameters Using Successive Correction Method

by Teizi Henmi

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Executive Summary

The successive correction method, a nowcasting method for surface meteorological parameters, such as temperature, dew point temperature, and horizontal wind vector components, was evaluated statistically by using data from the Mesowest mesonet. Nowcasting is a method of diagnosing the current weather situation, and in this study is defined as an objective analysis of meteorological parameters that are currently observed. The present nowcasting method uses the Battlescale Forecast Model (BFM) forecast fields of surface meteorological parameters as background data in combination with observation data.

Major findings of the present study included in this report are:

1. Temperature and dew point temperature can be accurately nowcasted by using the successive correction method. The BFM forecast data provided good background gridded data for these parameters. The combination of the observed data and good background data resulted in surface temperature fields and dew point temperature fields that accurately represent the current fields.

2. Surface horizontal wind vector fields were greatly improved by the nowcasting method over the BFM forecast fields. The BFM forecasting calculation alone could not produce reliable surface wind vector fields, but by combining the forecast with observation, much more improved wind fields can be obtained.

Finally, in the Conclusions section, this report suggests that a similar study should be conducted in the near future using the Penn State/National Center for Atmospheric Research (NCAR) Mesoscale Model version 5 (MM5) data as the background data

1. Introduction

Mesoscale forecasting models, such as the Battlescale Forecast Model (BFM), and the Penn-State/National Center for Atmospheric Research (NCAR) Mesoscale Model version 5 (MM5), produce short-range forecasting fields of surface meteorological parameters that are sometimes far from reality, particularly when applied to areas of complex terrain, such as the terrain found in Utah (Henmi, 2002).

This report describes the method of nowcasting surface meteorological parameters by combining model forecast data with observed data, and then discusses the results of applying the nowcasting method. Nowcasting is a method of diagnosing the current weather situation, and in this study is defined as an objective analysis of meteorological parameters that are currently observed. If the current weather situations are accurately diagnosed, it may be possible to accurately forecast near-future weather situations.

The successive correction method (Sashegyi and Madala, 1994), described in this report, has been successfully applied to nowcasting surface meteorological parameters over Oklahoma in a previous study (Sauter, Henmi, and Dumais, 2001). In the previous study, the BFM forecasting calculations were made over a model domain area of 600×600 km, with a 61×61 grid mesh and 10 km grid increments. Surface fields, including horizontal wind vector components, temperature, and dew point temperature, which were forecasted by the BFM, were combined with the observed data from several sites in the Oklahoma mesonet by the successive correction method. Nowcasted fields of the surface meteorological parameters were then compared with the rest of the mesonet data. The results of the study showed that combining surface observation data with the BFM forecast fields could produce more accurate fields of the surface meteorological parameters than model forecasting calculations, or the objective analysis of observed data, could determine individually.

The purpose of this study is to examine and statistically evaluate the successive correction method as a tool for nowcasting the surface meteorological parameters over a complex terrain area. The BFM forecast data is used as background data for the method. Details of the method are described in the following section. The model domain over Utah was chosen for this study because of the complexity of the terrain and the abundance of public meteorological data, which is available at no cost on the Internet.

2. Description of the BFM and Meteorological Data

2.1 BFM

The BFM is an operational forecast model developed by the U.S. Army Research Laboratory (ARL) (Henmi and Dumais, 1998). It has been extensively used to make short-range forecasts of atmospheric conditions as a component in the Integrated Meteorology System (IMETS). The BFM uses, for prognostic calculation, the Higher Order Turbulence Model for Atmospheric Calculation (HOTMAC), which was developed by Yamada (Yamada and Bunker, 1989). In operational mode in the IMETS, the BFM has been used over the model domain of 500x500 km^2 with the grid increment of 10 km.

In this study, the BFM is used over a model domain of 125x125 km^2, with the 2.5 km grid increments and 51x51 grid points, centered at 40.5 °N and 112 °W, as displayed in figure 1. The sites designated by "S" and "*" in figure 1 represent the locations of Mesowest observation sites. Observed data at the "S" sites were used for nowcasting calculations, and the observation data at the "*" sites were used for evaluating the results of nowcasting calculations. The selection of the "S" sites was made arbitrarily, and the number of sites used (18), was determined from pre-trials of the successive correction method.

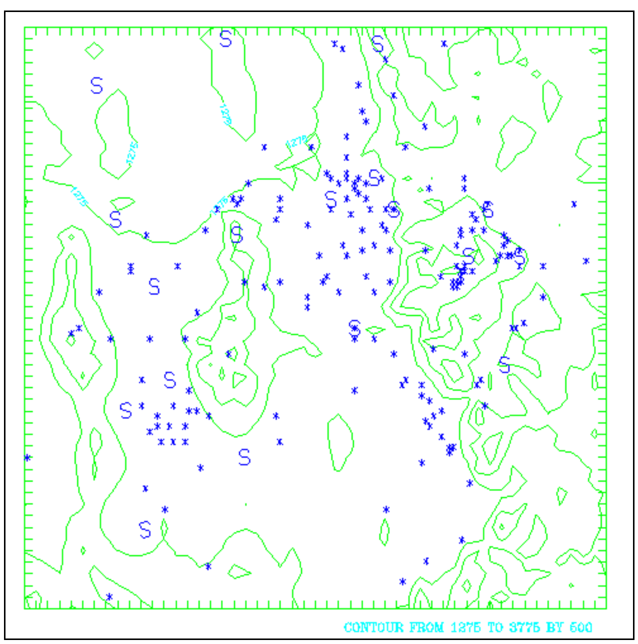

Figure 1. Terrain contours of the BFM model domain.

2.2 Meteorological Data

As seen in figure 1, there are numerous surface observation data available for the model domains. The data is publicly available from the University of Utah Mesowest cooperative anonymous File Transfer Protocol (FTP) site.

Mesowest data, contained in a file called total.dat, includes data for the past 24-h period, in 15 min intervals, for the western United States. A detailed description of Mesowest data can be found in Horel et al. (2002).

For this study, daily data files that contained data only at even hours, starting at 00:00 UTC (universal time coordinate) for a 24-h period, were produced for the study area. Table 1 illustrates a portion of the file containing daily data . The table shows the following (from left to right): station name, day, hour, minute, latitude, longitude, wind direction, wind speed (knots), temperature (°F), dew point temperature (°F), relative humidity (%), and 24-h accumulated precipitation.

Table 1. Portion of daily data.

BGRUT	2	516	0	0	40.93	-112.56	90.00	7.80	62.00	35.50	37.00-9999.00
BR4	2	516	0	0	41.44	-112.16	148.00	0.90	65.00	27.40	24.00-9999.00
DVB	2	516	0	0	40.62	-111.48	248.00	2.60	56.00	19.70	24.00-9999.00
EMPUT	2	516	0	0	40.61	-111.53	245.00	4.30	45.00	20.30	37.00-9999.00
FPK	2	516	0	0	41.03	-111.84	323.00	13.00	38.00	8.50	29.00-9999.00
FWP	2	516	0	0	40.66	-112.20	244.00	3.50	43.00	17.20	35.00-9999.00
GNI	2	516	0	0	41.33	-112.85	96.00	8.70	62.00	29.40	29.00-9999.00
HAT	2	516	0	0	41.07	-112.59	42.00	7.00	62.00	23.80	23.00-9999.00
LDS1	2	516	0	0	40.77	-111.89	359.00	3.50	63.00	17.50	17.00-9999.00
LMR	2	516	0	0	41.06	-112.89	104.00	0.00	60.00	22.10	23.00-9999.00
LMS	2	516	0	0	41.70	-112.85	148.00	2.60	67.00	20.80	17.00-9999.00
MBY	2	516	0	0	40.61	-111.48	282.00	9.60	48.00	16.50	28.00-9999.00
PCB	2	516	0	0	40.65	-111.51	347.00	1.70	60.00	24.10	25.00-9999.00
PCS	2	516	0	0	40.65	-111.52	266.00	1.70	55.00	20.80	26.00-9999.00
PRP	2	516	0	0	41.26	-112.44	341.00	6.10	53.00	10.60	18.00-9999.00
SB1	2	516	0	0	41.19	-111.84	312.00	3.50	55.00	13.50	19.00-9999.00
SNH	2	516	0	0	40.55	-111.85	340.00	4.30	65.00	26.30	23.00-9999.00
SNI	2	516	0	0	41.20	-111.86	20.00	0.90	50.00	15.60	25.00-9999.00
SNV	2	516	0	0	40.62	-111.51	269.00	0.90	52.00	20.70	29.00-9999.00
SNX	2	516	0	0	41.04	-112.23	48.00	4.30	62.00	27.70	27.00-9999.00
SNZ	2	516	0	0	40.88	-111.87	339.00	0.00	66.00	25.00	21.00-9999.00
TPC	2	516	0	0	40.43	-111.71	192.00	4.30	52.00	23.10	32.00-9999.00
WBU	2	516	0	0	40.71	-111.56	271.00	4.30	61.00	25.00	25.00-9999.00
WCR	2	516	0	0	40.55	-111.32	261.00	7.80	57.00	16.30	20.00-9999.00
KMS	2	516	0	0	40.56	-111.13	253.00	3.50	57.00	18.50	22.00-9999.00
SKY	2	516	0	0	39.58	-111.25	249.00	8.70	52.00	16.30	24.00-9999.00
UT1	2	516	0	0	41.20	-111.11	225.00	10.50	56.10	16.20	20.00-9999.00
UT12	2	516	0	0	40.64	-111.90	0.00	5.80	66.00	21.90	18.00-9999.00
UT20	2	516	0	0	40.75	-111.90	337.50	6.80	66.70	20.80	17.00-9999.00
UT23	2	516	0	0	40.72	-111.90	0.00	7.20	67.60	20.70	16.00-9999.00
UT5	2	516	0	0	40.71	-111.80	270.00	6.00	64.90	17.20	15.00-9999.00
UT7	2	516	0	0	40.48	-111.90	0.00	12.60	65.10	19.90	17.00-9999.00
UT9	2	516	0	0	40.68	-112.26	22.50	15.60	63.10	23.40	22.00-9999.00
SND	2	516	0	0	40.37	-111.59	167.00	7.00	55.00	19.80	25.00-9999.00
QSA	2	516	0	0	40.83	-112.01	5.00	7.00	63.00	22.50	21.00-9999.00
KEM	2	516	0	0	41.76	-110.58	270.00	16.50	54.00	25.60	33.00-9999.00

Table 1. Portion of daily data (continued).

LGP	2	516	0	0	41.71	-111.71	288.00	10.40	36.00	14.60	41.00-9999.00
CASD	2	516	0	0	39.22	-111.02	257.40	8.80	74.10	28.20	18.20-9999.00
ELMO	2	516	0	0	39.40	-110.81	286.60	5.90	77.00	20.60	12.10-9999.00
FERR	2	516	0	0	39.09	-111.09	359.30	11.60	68.80	17.70	14.10-9999.00
GUNN	2	516	0	0	39.16	-111.81	333.20	11.20	74.60	27.00	17.00-9999.00
LITW	2	516	0	0	39.32	-111.33	339.80	7.20	67.50	33.90	28.80-9999.00
MOLE	2	516	0	0	39.06	-111.14	202.50	10.50	70.90	18.20	13.30-9999.00
CUPC	2	516	0	0	40.36	-111.90	333.40	6.30	67.20	27.40	22.30-9999.00
CUPE	2	516	0	0	40.49	-111.47	255.40	6.30	65.80	25.90	22.00-9999.00
CUPF	2	516	0	0	40.22	-111.11	273.60	11.70	54.60	31.00	40.40-9999.00
CUPG	2	516	0	0	40.37	-111.03	355.30	7.30	54.40	30.30	39.50-9999.00
CUPI	2	516	0	0	40.56	-110.70	354.40	0.00	55.80	14.60	19.40-9999.00
MSI01	2	516	0	0	40.72	-111.86	325.00	5.60	69.70	25.60	19.00-9999.00
BBN	2	516	0	0	40.89	-111.85	330.00	2.60	63.00	17.50	17.00-9999.00
ARAU1	2	516	0	0	40.59	-113.02	40.00	6.10	64.00	13.00	14.00-9999.00
BRAU1	2	516	0	0	40.88	-110.83	90.00	4.30	54.	9.00	26.00-9999.00

The Navy Operational Global Atmospheric Prediction System (NOGAPS) data, which provides information globally for every 1° grid point, was used for initialization and time-dependent lateral boundary conditions of the BFM. The forecast data for the periods of 0-h, 12-h, and 24-h, initialized at 00:00 UTC, was obtained at 13 pressure levels between 1000 mb and 100 mb. The data was obtained through the Defense Modeling and Simulation Office (DMSO), Master Environmental Library (MEL) Web site. Upper-air sounding data was obtained from the University of Wyoming Web site.

For this study, data archived for the period of January-March 2002 was used. Table 2 shows the dates of the archived data used for model calculations of 24-h forecasting.

Table 2. Dates of archived data used.

Month, 2002	Days
January	15, 22, 23, 24, 25, 28, 29, 30
February	4, 5, 6, 7, 8, 11, 12, 13, 14, 19, 20, 21, 22, 26, 27, 28
March	4, 5, 6, 7, 8, 11, 12, 14

3. Nowcasting and Evaluation Methods

3.1 Nowcasting Method

From the NOGAPS data, horizontal wind vector components, temperature, dew point temperature and geopotential height at 13 different pressure levels for the forecast periods of 00:00–12:00 UTC, and 12:00–24:00 UTC are interpolated at each pressure level. The data is then vertically interpolated from the pressure levels to the BFM's height levels. The 0-h data produced for the height levels is then combined with upper air sounding data obtained at Salt Lake City, Utah. The BFM forecasting calculations of two 12-h periods per day are made by using this data as the initialization and lateral boundary condition data. Details of the BFM forecasting method are described in Henmi and Dumais (1998).

The BFM forecasting data, containing hourly data, is used as the background data for the nowcasting method for surface temperature, dew point temperature, and horizontal wind vector components, u and v. The successive correction method (Sashegyi and Madala, 1994) that follows is used in this study:

If $x_a(i,j)$ is the nowcasted value at the grid point (i, j), and $x_b(i,j)$ is the value of the background (also known as the first guess) at the grid point, we can write:

$$x_a(i,j) = x_b(i,j) + \sum_{k=1}^{m} w_{k,ij}(x_{o,k} - x_{b,k}) \tag{1}$$

where

> $x_{o,k}$ is the observation at the k^{th} location, $w_{k,ij}$ is the weight for each observation, $x_{b,k}$ is the value of the background at the observation point derived by a bilinear interpolation method (described in the next section), and m is the number of observations.

In this study, the weighting factor is defined as:

$$w_{k,ij} = \frac{1}{r^2_{k,ij}} \tag{2}$$

where

> $r_{k,ij}$ is the distance between k^{th} observation point to grid point (i, j).

The method is repeated in iterative fashion, so that the background field is updated by the latest analysis after each iteration:

$$x_a(n+1) = x_a(n) + \sum_{k=1}^{m} w_{k,ij}(x_{o,k} - x_{a,k}(n)) \tag{3}$$

where

> $x_a(n)$ is the value of the analysis at the grid point after the n^{th} iteration, and $x_{a,k}$ is its value interpolated for k^{th} location after the n^{th} iteration.

In this study, the iteration was repeated three times to obtain the final values.

Figures 2, 3, and 4 illustrate the nowcasting procedures. Figure 2 shows surface wind vectors observed at 00:00 UTC, March 5, 2002, while figure 3 shows surface wind vector fields forecasted by the BFM for 00:00 UTC, March 5, 2002. The data displayed in both figure 2 and 3 were used for the nowcasting calculation (displayed in figure 4).

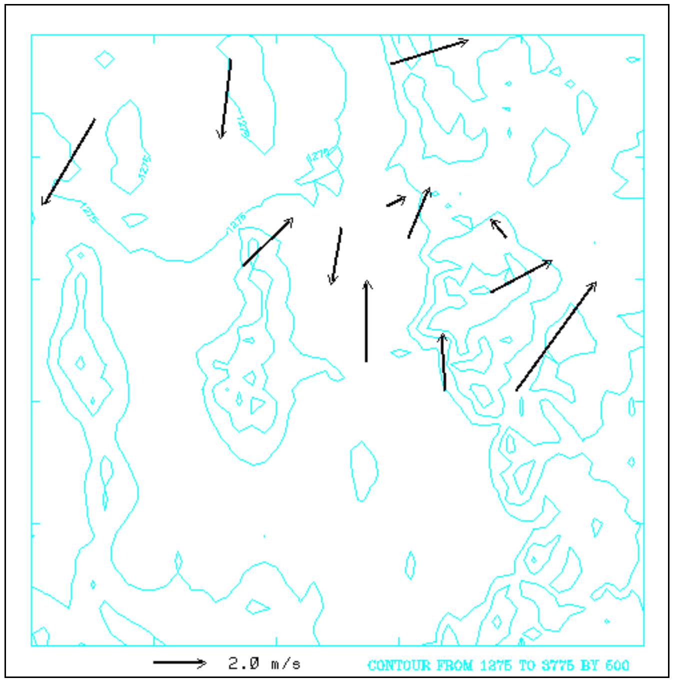

Figure 2. Surface wind vectors observed at 00:00 UTC, March 5 2002.

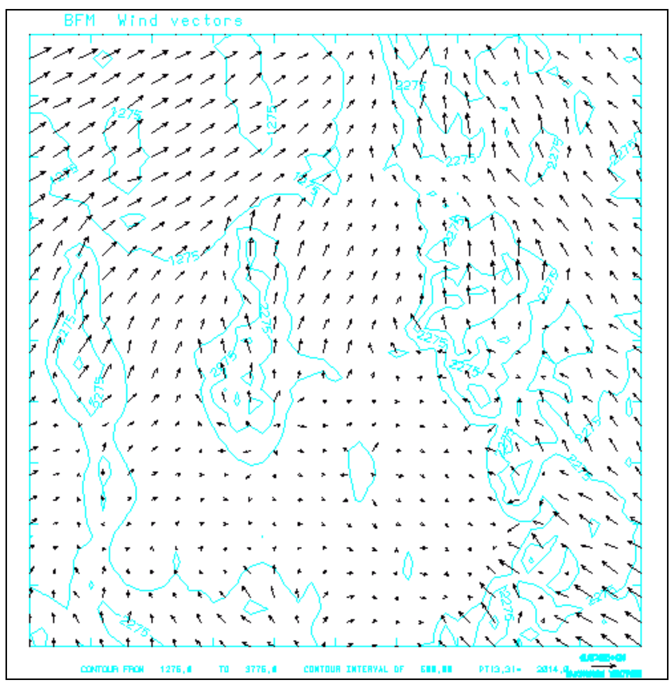

Figure 3. Surface wind vector field forecasted by the BFM for 00:00 UTC, March 5 2002.

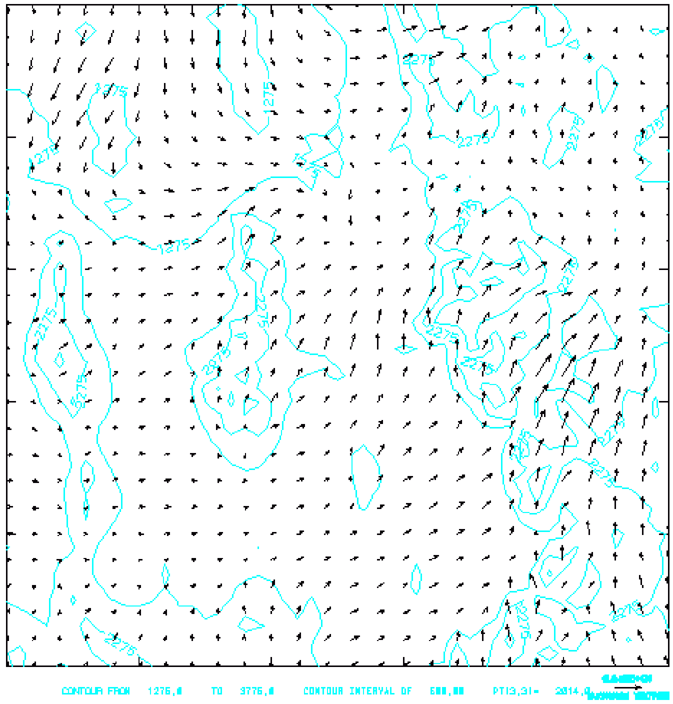

Figure 4. Wind vector field nowcasted by the successive correction method.

3.2 Evaluation Method

3.2.1 Data Comparison Method

After the nowcasting calculation is completed, the bilinear interpolation is conducted to obtain the nowcasted data at the locations of surface observation sites.

Suppose a surface observation location (x' and y') is surrounded by four model grid points. An interpolated value, φ', of an arbitrary variable, φ at (x', y'), is calculated using a bilinear interpolation method, such as:

$$\varphi_1=\varphi(i, j)+(x' - x)[\varphi(i+1, j) - \varphi(i, j)]$$

$$\varphi_2= \varphi(i, j+1) +(x' - x)[\varphi(i+1, j+1) - \varphi(i, j+1)]$$

$$\varphi'(x', y')=\varphi_1 + (y'-y)[\varphi_2 - \varphi_1] \quad (4)$$

where

(i, j) is the southwest grid point of the four grid points surrounding a surface observation location (x', y'), and (x, y) is the location for the grid point (i, j): φ(i, j) is an arbitrary variable at (x, y).

3.2.2 Statistical Parameters

The following statistical parameters between nowcasted data and surface observation data are calculated using the data available in the model domain. The parameters are calculated hourly for the entire nowcasting period. Statistical parameters are calculated for temperature, relative humidity, wind speed, and horizontal wind vector components, u and v.

Mean Difference (MD):

$$MD = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}(x_{p,i,j} - x_{o,i,j})}{mn}$$

(5)

where

the subscripts o and p represent observation and prediction, respectively. The subscript i represents the i^{th} surface station, and the subscript j represents the j^{th} forecast day. n is the number of surface stations, and m is the total number of forecast days.

A nonzero mean difference (MD) indicates bias. For instance, if the MD value is positive, it indicates that the model tends to over-forecast.

Mean Absolute Difference (AD):

$$AD = \frac{\sum\sum\left|x_{p,i,j} - x_{o,i,j}\right|}{mn} \tag{6}$$

Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{\sum_{j=1}^{m}\sum_{i=1}^{n}(x_{p,i,j} - x_{o,i,j})^2}{mn}} \tag{7}$$

Good agreements between observation and forecast are, in general, related to smaller values of AD and RMSE.

Root Mean Square Vector Error (RMSVE):

$$RMSVE = \sqrt{\frac{\sum\sum[(u_{o,i,j} - u_{p,i,j})^2 + (v_{o,i,j} - v_{p,i,j})^2]}{mn}} \tag{8}$$

This parameter measures the differences of both wind speed and wind direction. Good agreements of wind vectors are related to small values of the RMSVE.

Correlation Coefficient (CC):

$$CC = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} y_{o,i,j}\, y_{p,i,j}}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n} y_{o,i,j}^2 \sum_{i=1}^{m}\sum_{j=1}^{n} y_{p,i,j}^2}} \tag{9}$$

Here:

$$y_{o,i,j} = x_{o,i,j} - \overline{x_o}$$
$$y_{p,i,j} = x_{p,i,j} - \overline{x_p}$$

and x_o and x_p are the means of observed and forecast values, respectively.

Mean Wind Direction Difference (MWDDF):

$$MWDDF = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}\left|\theta_{p,i,j} - \theta_{o,i,j}\right|}{mn} \qquad (10)$$

where

θ is the wind direction.

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4. Results

4.1 Nowecasted and Observed Data Comparison

Figures 5 through 9 show scatter diagrams that compare nowcasted data and observed data. These figures represent twelve hour data between 00:00 and 12:00 UTC, during the period of January-March (31 days), 2002. As mentioned previously, nowcasted fields were calculated by the successive correction method from the BFM forecast data and the observation data at the "S" sites that are shown in figure 1. Observation data used for these scatter diagrams is obtained only from the "*" sites that are shown in figure 1.

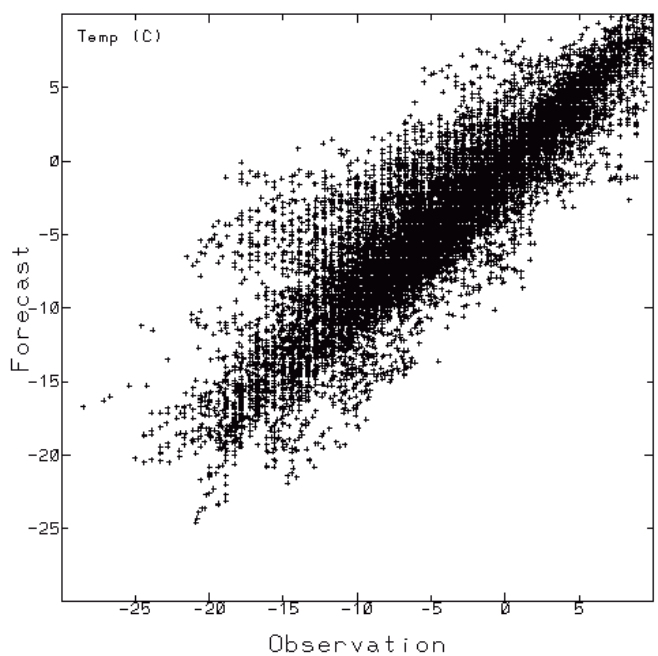

Figure 5. Temperature comparison between the nowcasted data and the observed data.

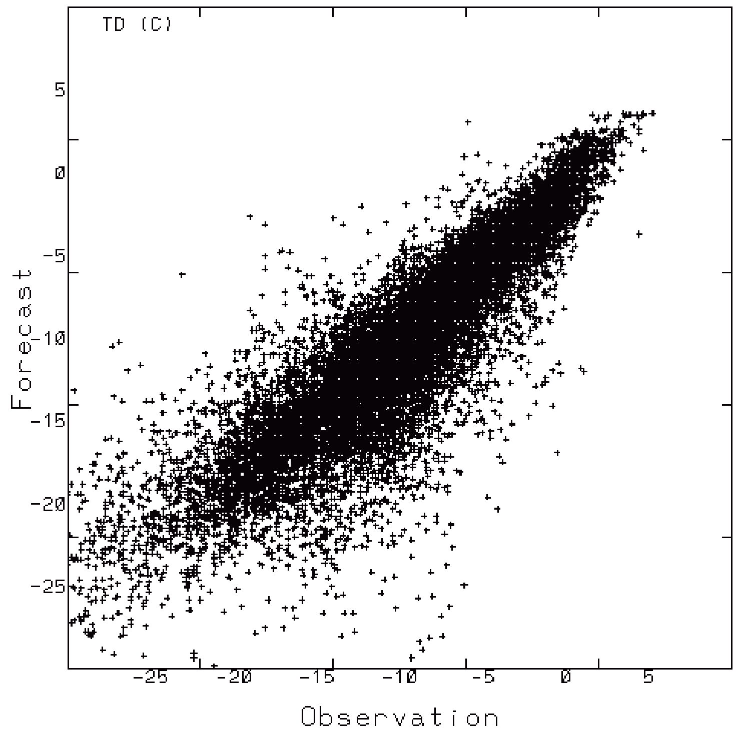

Figure 6. Dew point temperature comparison between the nowcasted data and the observed data.

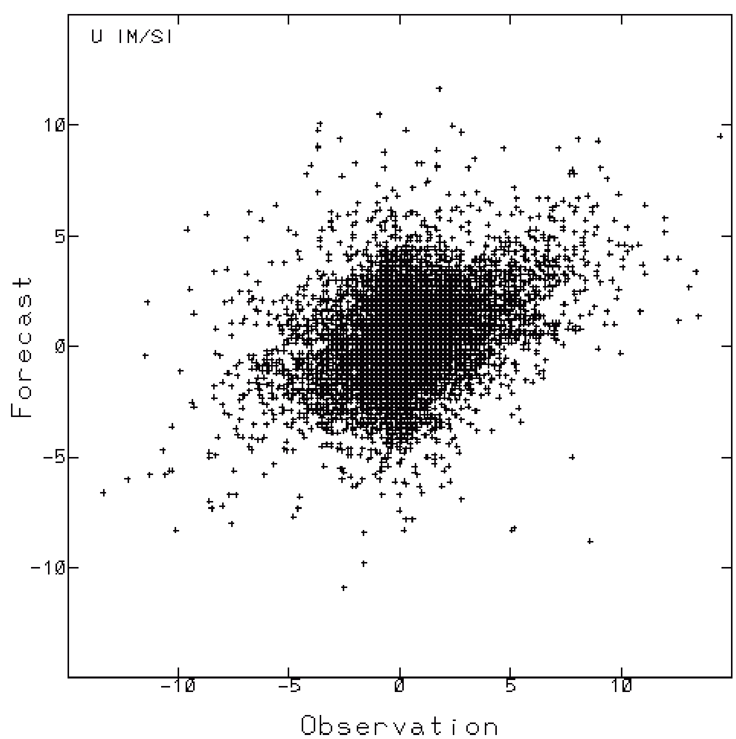

Figure 7. Wind vector-x component u comparison between the nowcasted data and the observed data.

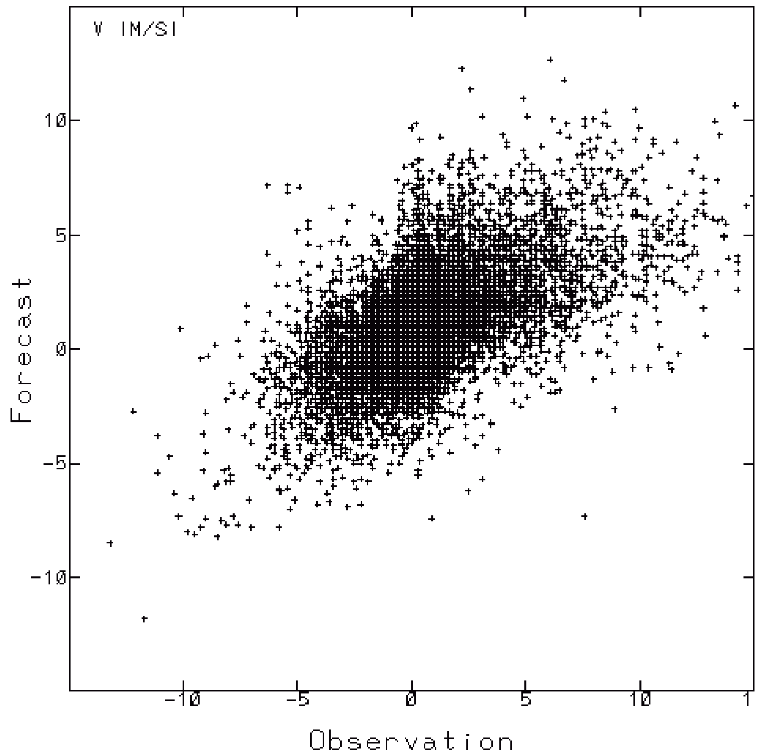

Figure 8. Wind vector-y component v comparison between the nowcasted data and the observed data.

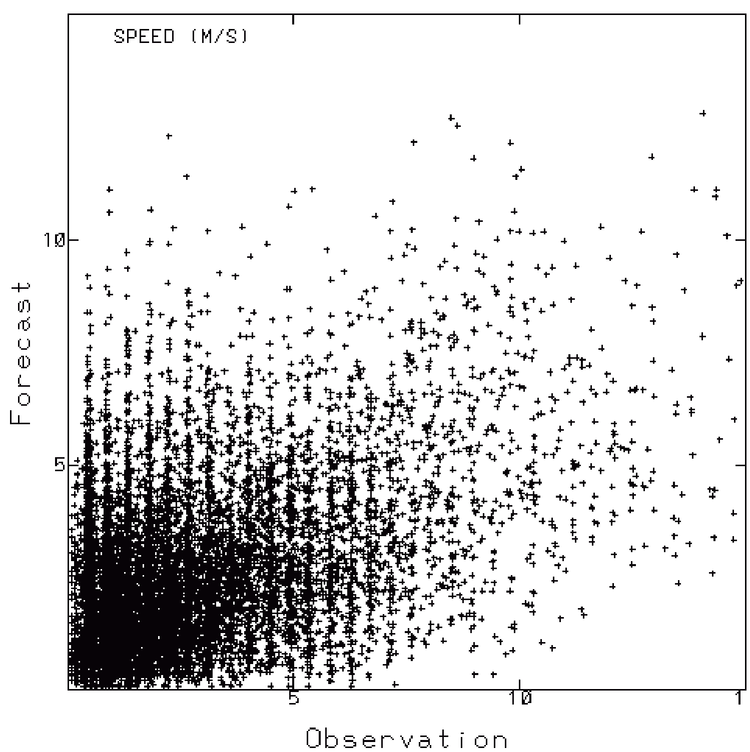

Figure 9. Wind speed comparison between the nowcasted data and the observed data.

Statistical parameters for figures 5–9 are calculated in table 3. These parameters are calculated for the data obtained from "*" sites in the nowcasting hours of 00:00–12:00 UTC, during the period of January-March (31 days), 2002. The parameters are calculated for the nowcasted data by the successive correction method using the BFM forecast data, and the 20-station data, which is marked by "S" in figure 1. The observed data was obtained at the stations marked by "*" in figure 1, and are used for these statistics.

Table 3. Statistical parameters calculated for the nowcasted data by the successive correction method. RMSVE = 2.8 m/sec, and MAWDD = 43°.

Parameters	**Temperature (°C)**	**Dew Pt. Temp.(°F)**	**U (m/sec)**	**V(m/sec)**	**Speed(m/sec)**
CC	.89	.88	.36	.58	.46
MD	.6	-.4	.1	.3	-.1
AD	2.0	2.1	1.6	1.7	1.7
RMSE	3.0	3.1	2.3	2.4	2.3
Number of Data	16,015	16,120	12,546	12,546	12,546

The statistics comparison between the nowcasted data and the observed surface data, including all the sites ("S" and "*") for the same data set, are given in table 4, which shows that the values are superior to table 3. By using the successive correction method, the agreements at "S" sites between calculated and observed values are almost perfect.

Table 4. Statistical parameters calculated for the nowcasted data by the successive correction method using data from both "S" and "*" sites. RMSVE = 2.8 m/sec, and MAWDD = 26.2°.

Parameters	**Temperature (°C)**	**Dew Pt. Temp. (°C)**	**U (m/sec)**	**V (m/sec)**	**Speed (m/sec)**
CC	.92	.92	.62	.73	.63
MD	.4	-.3	.0	.2	.0
AD	1.4	1.5	1.1	1.2	1.1
RMSE	2.5	2.6	1.9	2.0	1.9
Number of Data	21,503	21,705	17,773	17,773	17,608

Similar statistics between the BFM forecast data and the observation data, including both "S" and "*" sites shown in figure 1, are given in table 5 for the same data period as the period used for figure 3.

Table 5. Statistical parameters between the BFM forecast data and the observed data at both "S" and "*" sites. RMSVE = 3.9 m/sec, and MAWDD = 55.2°.

Parameters	Temperature (°C)	Dew Pt. Temp. (°C)	U (m/sec)	V (m/sec)	Speed (m/sec)
CC	.84	.79	.28	.39	.28
MD	.2	-2.6	.6	.0	-.3
AD	2.4	3.9	1.9	1.9	1.9
RMSE	3.4	4.8	2.7	2.8	2.6
Number of Data	21,614	21,723	17,753	17,753	17,753

As seen when comparing tables 4 and 5, the nowcast data, as a whole, produces better statistical results than the BFM forecast data. In particular, the wind field statistics produced by nowcasting are substantially improved when compared to those produced by forecasting.

4.2 Time Series of the Statistical Parameters

As mentioned in section 3, "Nowcasting and Evaluation Methods," the BFM forecast calculations are done twice a day for 12 hour (00:00–12:00 UTC), and two files containing forecast data for 12-h periods are produced before the nowcasting calculation.

Time series of the statistical parameters, MD, CC, and AD are shown in figures 10(A) and (B), 11(A) and (B), and 12(A) and (B). The time series of these parameters, calculated between the nowcasted data and the observed data from both the "S" and "*" sites, are shown in figures 10(A), 11(A), and 12(A). For comparison, those parameters calculated between the BFM forecast data and the observed data are shown in figures 10(B), 11(B), and 12(B). Figures 10, 11, and 12 represent, respectively, temperature, dew point temperature, and wind speed. Figures 13(A) and 13(B) represent the root mean square vector error (RMSVE) and mean wind direction difference (MWDDF). The calculations are made every hour during two 12-h periods, using the data for 31 days in the period of January through March 2002.

In these figures, thin lines represent the period between 00 and 12 h, and thick lines represent the period between 12 and 24 h.

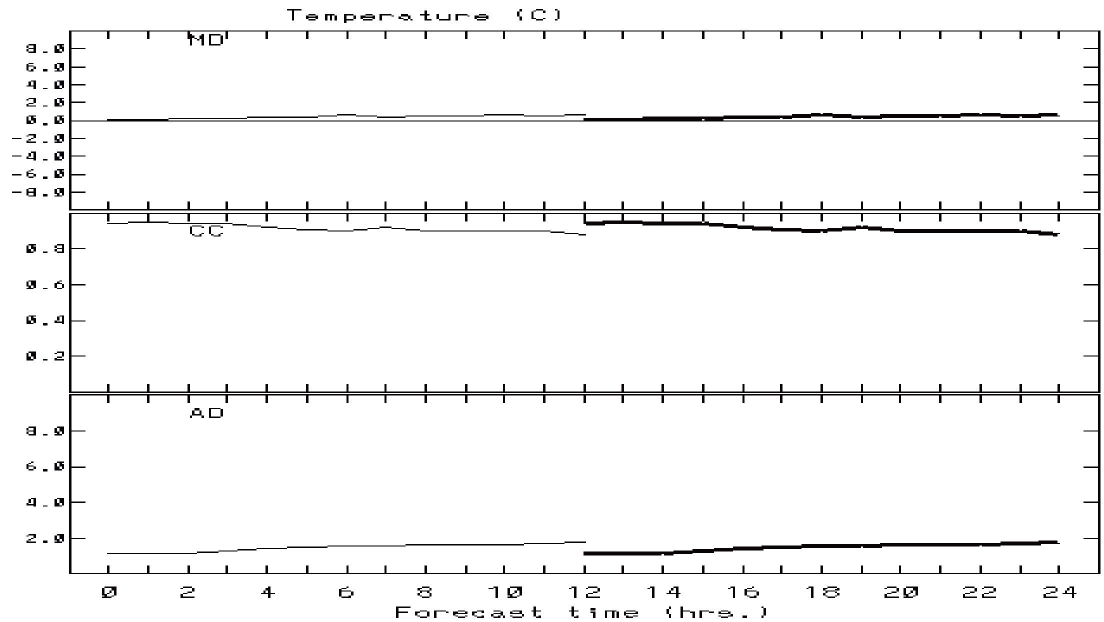

Figure 10(A). Time series of statistical parameters for temperature between the nowcasted data and the observed data from both "S" and "*" sites.

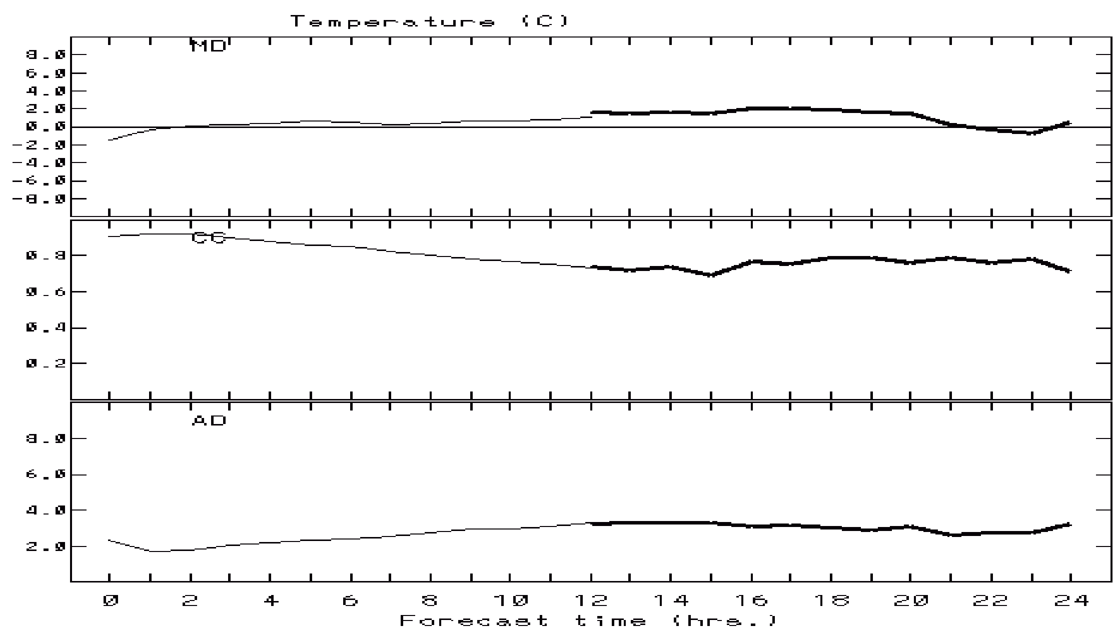

Figure 10(B). Time series of the statistical parameters for temperature between forecasted data by BFM and the observed data from both "S" and "*" sites.

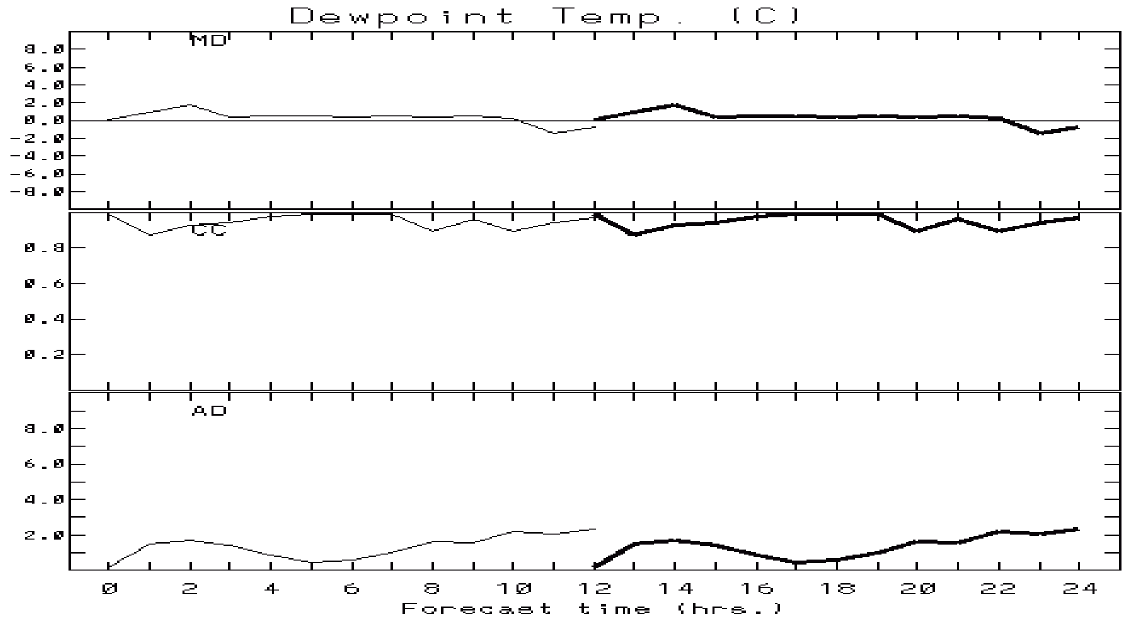

Figure 11(A). Time series of statistical parameters for dew point temperature between the nowcasted data and the observed data from both "S" and "*" sites.

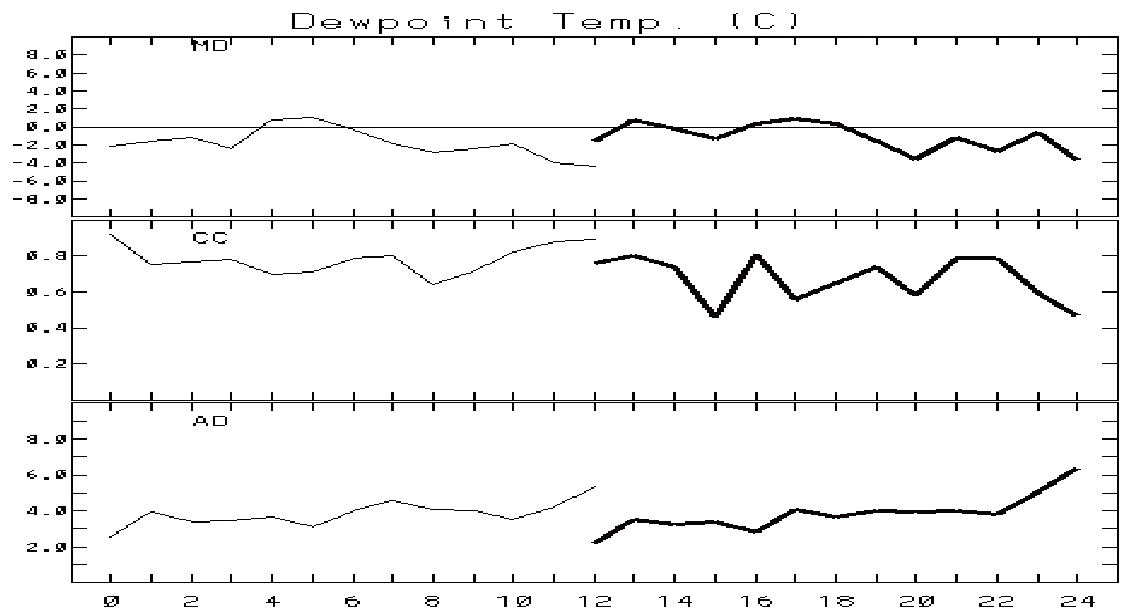

Figure 11(B). Time series of the statistical parameters for dew point temperature between forecasted data by BFM and the observed data from both "S" and "*" sites.

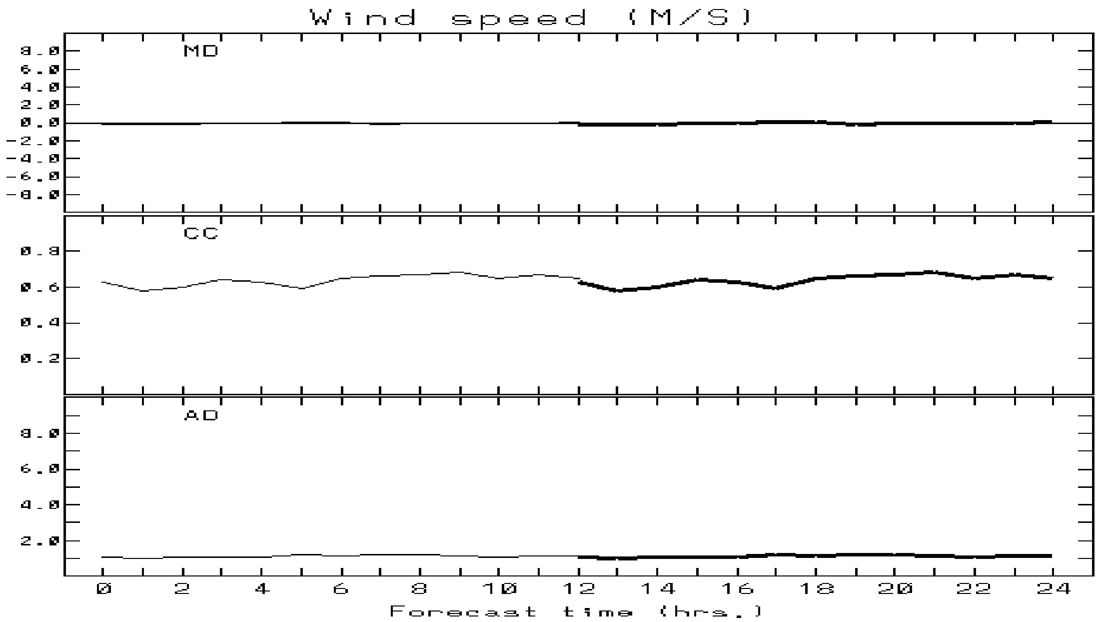

Figure 12(A). Time series of statistical parameters for wind speed between the nowcasted data and the observed data from both "S" and "*" sites.

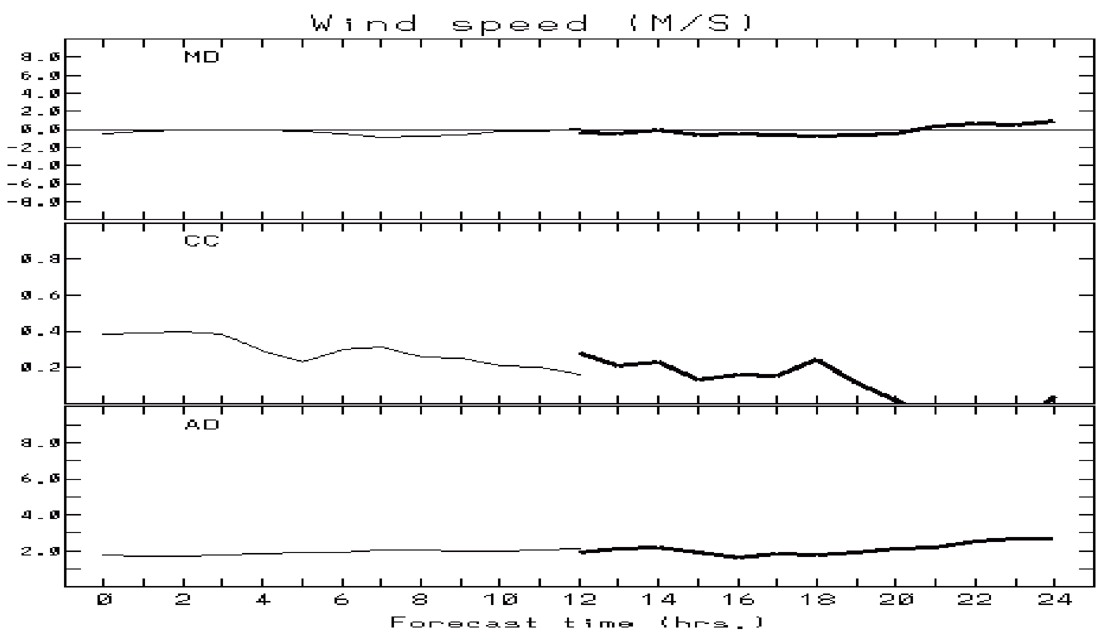

Figure 12(B). Time series of the statistical parameters for wind speed between forecasted data by BFM and the observed data from both "S" and "*" sites.

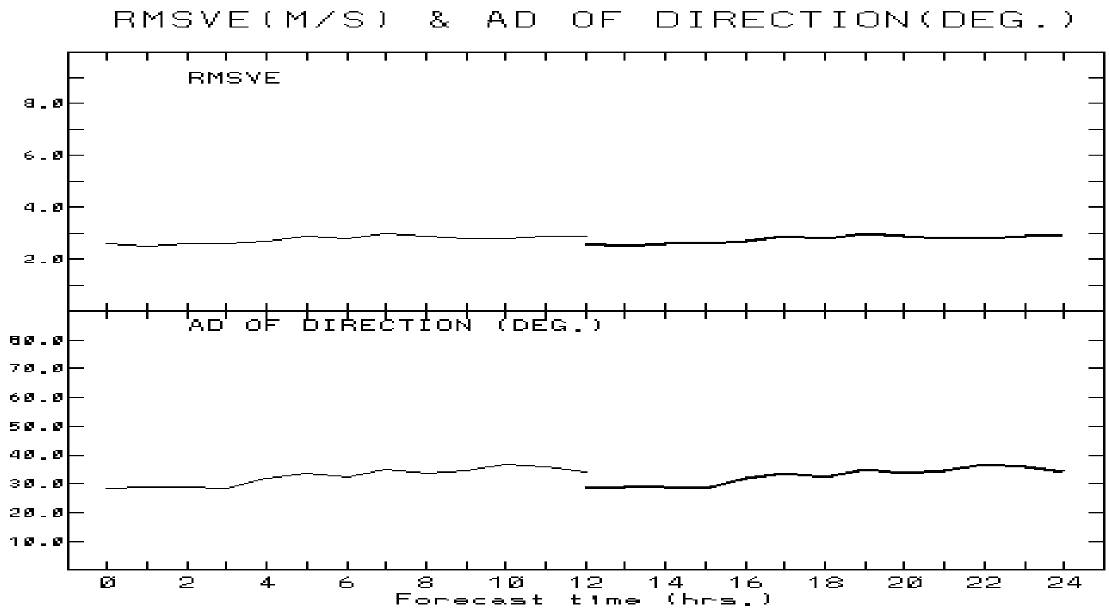

Figure 13(A). Time series of RMSVE and MWDDF between the nowcasted data and the observed data from both "S" and "*" sites.

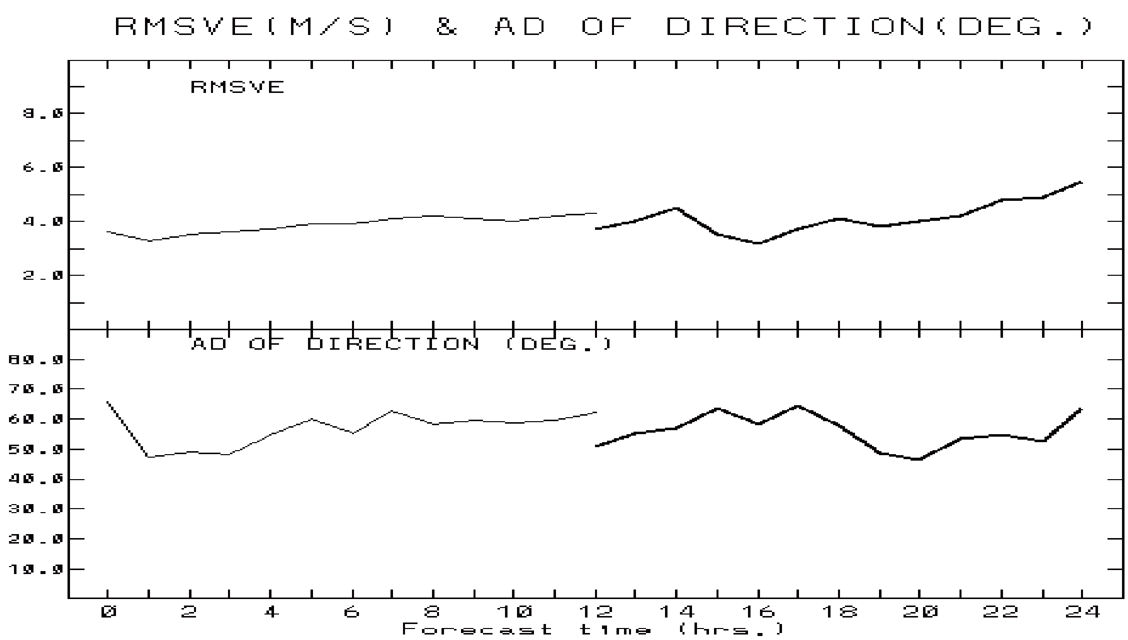

Figure 13(B). Time series of RMSVE and MWDDF between the forecast data by BFM and the observed data from both "S" and "*" sites.

Figures 10(B) and 11(B) show that temperature and dew point temperature fields at the surface can be forecasted fairly well by the BFM. However, figures 10(A) and 11(A) show that the nowcasting method further improves the agreements between calculation and observation.

From figures 12(B) and 13(B), it is inferred that forecasting the surface wind vector fields by the BFM should be substantially improved. By combining the forecast fields with observed data, substantially improved wind vector fields were obtained. The mean AD of wind speed is improved from about 2 m/sec to 1 m/sec, the CC of wind speed from less than 0.4 to about 0.6, and the MWDDF from 60° to 30°.

5. Conclusions

The successive correction method was examined and evaluated statistically as a nowcasting tool for surface meteorological parameters, including temperature, dew point temperature, and horizontal wind vector components. The BFM forecast fields of the surface meteorological parameters were used as background data.

In a study that was done over the model domain of Oklahoma, statistical results similar to the results achieved in this study were obtained by using observed data that was taken at only three or five sites (Sauter, Henmi, and Dumais, 2001). In addition, the model domain size of Oklahoma was 600x600 km^2 with 10 km grid increments. The current study used data obtained at 18 stations over the model domain of 125x125 km^2 with 2.5 km grid increments.

By using the successive correction method, temperature and dew point temperature can be nowcasted well. The major reason for this is that the BFM forecasting calculation could provide good background fields of surface temperature and dew point temperature.

Surface horizontal wind vector fields were really improved by the nowcasting calculation over the BFM forecast fields. The BFM forecast calculation alone could not produce reliable surface wind vector fields, but by combining the forecast with observation, much more improved wind fields could be obtained.

In the mesoscale model evaluation study of the MM5 and the BFM over the model domains of Utah, a model similar to the model of the present study (Henmi, 2002), it was found that the MM5 could produce better surface meteorological forecast data than the BFM. Therefore, if the fields produced by the MM5 were used as the background data, the study might have obtained better statistical results than those obtained by using the BFM forecast data. A similar study using the MM5 data as the background data will be conducted in the near future.

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Acronyms

AD	Absolute Difference
ARL	U.S. Army Research Laboratory
BFM	Battlefield Forecast Model
CC	Correlation Coefficient
DMSO	Defense Modeling and Simulation Office
FTP	File Transfer Protocol
HOTMAC	Higher Order Turbulence Model for Atmospheric Circulation
IMETS	Integrated Meteorology System
MWDDF	Mean Absolute Wind Direction Difference
MD	Mean Difference
MEL	Master Environmental Library
MM5	Mesoscale Model version 5
NCAR	National Center for Atmospheric Research
NOGAPS	Navy Operational Global Atmospheric Prediction System
RMSE	Root Mean Square Error
RMSVE	Root Mean Square Vector Error
UTC	Universal Time Coordinate

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14. ABSTRACT

The successive correction method was examined and evaluated statistically as a nowcasting method for surface meteorological parameters including temperature, dew point temperature, and horizontal wind vector components. The Battlescale Forecast Model (BFM) forecast fields of the surface meteorological parameters were used as background data.

By this method, temperature and dew point temperature could be nowcasted well. The major reason for this is that the BFM forecasting calculation could provide good background fields of surface temperature and dew point temperature. Surface horizontal wind vector fields were really improved by the nowcasting calculation. The BFM forecast calculation alone could not produce reliable surface wind vector fields, but by combining the forecast data with observation, much more reliable wind field could be obtained than what would be determined by the BFM alone.

15. SUBJECT TERMS

Nowcasting, surface meteorological parameters, successive correction method

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