REPORTING MESOSCALE WEATHER PATTERNS VIA TV WEATHERCASTS IN THE TWIN CITIES

by

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1. INTRODUCTION

Television weathercasts across the country tend to have one element in common - the recitation of the official statistics provided by the National Weather Service, usually taken at the municipal airport. One frequently suspects that the public is more weatherwise than given credit for, and is muttering under their collective breath, "So, who lives at the airport?" Some TV stations will attempt to overcome this disparity between the observation point and the centers of population by providing local readings taken at the TV station which is typically located within the urbanized area. Often weathercasts will display regional weather conditions, but these are generally obtained from hourly aviation reports taken at stations perhaps a hundred miles apart. There is in fact, extreme mesoscale climatic variability within almost all TV station viewing areas, which typically cover 10,000 square miles, or more. Information on these variabilities both in a general and specific forecast sense are of great value to the public's economic activities including agribusiness, energy production and utilization, construction and other outdoor activities, flood control, sewer design and operation, etc.

Meteorological parameters change drastically with elevation in mountainous areas, where localized heavy snows and flash flooding are a constant threat (Henz, *et. al.*, 1976). Shoreline areas, especially around the Great Lakes, are known for their great ranges in temperature due to the moderating effect of the adjacent water (Lyons, 1972). Even cities located on broad, featureless prairies, are known to produce measureable effects on mesoscale weather patterns (Frisken, 1973). An intensive study of the St. Louis area (Principle Investigators of Project METROMEX 1976) show significant urban affects on cloud cover, precipitation intensity and coverage, hail, atmospheric chemical properties, low-level wind flows, and of course heat and moisture distribution. As would be expected the metropolitan Minneapolis/St. Paul area, only slightly smaller than St. Louis, also produces significant local weather alterations. In an intensive analysis of 14 years of rain gauge data presented by Kuehnast (1975), there is strong evidence of mesoscale variability in precipitation produced by the Twin Cities. Growing season precipitation differences from one part of the metropolitan area to another exceeded 20% over this time span.

Advances in meteorology's understanding of atmospheric behavior, and increases in the ability to collect, analyze, and disseminate data, are now such that mesoscale nowcasting can become a reality. Mesoscale in this context means variability in parameters over a scale of several miles. Nowcasting refers to the ability of meteorologists to properly analyze mesoscale phenomena such as thunderstorms, while they are still occurring, and distribute the data in useable form while the event is still in progress.

Television station KSTP has established an Observer Network of approximately two dozen stations with part of its goal being to provide mesoscale nowcasts to its viewers.

2. THE OBSERVER NETWORK

The KSTP Observer Network was formally initiated on 1 December 1975. It has grown to two dozen observing sites, including KSTP itself and the Weather Service Forecast Office (MSP) at the Twin Cities International Airport. Observers were selected with the assistance of the Minnesota State Climatologist, Mr. Earl Kuehnast. They were chosen on the basis of geographical distribution and proven reliability as cooperative observers. Their ages range from 14 to 81. Since the inception of the network the observers have proven very faithful indeed, providing greater than 90% data capture, and exceptionally low error rates.

Those observers not already possessing adequate equipment were supplied with a 4" x 4" redwood post, a small thermometer shelter to be mounted approximately 5 feet above grass, a 4" diameter plastic rain gauge, a calibrated mercury thermometer, and a maximum/minimum thermometer (Figure 1). KSTP staff members personally supervised the installation of most instrumentation, and detailed instructions for instrument siting and data taking were provided. An Observer Newsletter keeps participants updated on changes and procedures, and results obtained from the network. A meeting of the observers and their family members involved in the program resulted in over 70 enthusiastic participants.

Figure 1. The Wulff's, Observer Station 24, Cannon Falls, Minnesota (58 km southeast of KSTP) next to shelter containing the maximum thermometer, the mercury standard thermometer, and the 4" plastic rain gauge.

Figure 2. The KSTP Weather Service forecasting operations area, included in the view are the teletypes, facsimile, satellite laserfax receiver, colorized WSR-74c radar, and read outs for the 166 m instrument tower.

Each observing station reports via telephone between 5:00 and 5:30 p.m. each weekday. The reports are assembled by the duty meteorologist in the weather services operations area (Figure 2). Each observer calls in the current temperature, 24-hour high and low, total melted precipitation, snowfall, snow depth, sky state, and significant weather events of the last 24 hours. For broadcast, the data are displayed using a computer-like video character generator. The key-board operator (Figure 3) electronically displays a field of numbers (for example observed precipitation), which is then mixed through a video switcher to be displayed over a color slide of the Observer Network area for on-air presentation. The display covers an area of 69 x 77 miles (110 x 123 km), or 5,313 square miles (13,530 square kilometers). Thus reports presented on the 6:15 p.m. weathercast are frequently less than 1 hour old.

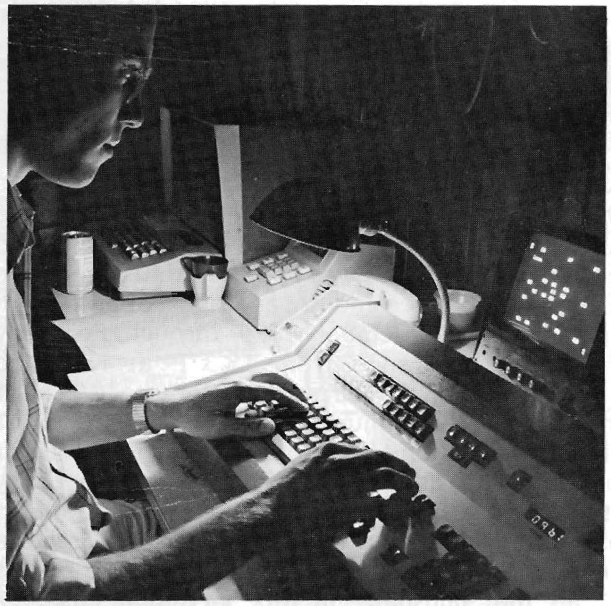

Figure 3. Entering Observer Network Data into computer character generator for display during weathercasts.

The Observer Network data has been extremely valuable in educating viewers to the realities of mesoscale weather variability and also in preparing the forecasts themselves. KSTP Weather Services integrates the Observer Network data with its other data sources, which include color animation display of the WSR-74c radar, GOES laserfax satellite images, teletype data from Service A, C, and RAWARC, NAFAX facsimile charts, and wind and temperature sensors at 70, 170, and 520 foot (21, 52, and 159 meters) levels on our auxiliary tower.

The sites chosen are a mixture of urban, suburban, rural and low-lying river bottom areas. The KSTP site is the only one that is not located above a grassy area. A thermograph is enclosed within a standard Stevenson screen located on the roof of a two-story building at KSTP, which is located in an urbanized area halfway between the respective downtowns of Minneapolis and St. Paul. It is felt that this site is a representative reading for temperatures within the urban canyons themselves. Therefore its nominally poor exposure can be thought of as useful data.

3. SOME RESULTS

When designing the Observer Network, mesoscale variations were expected to be found. The urban heat island, however, was somewhat stronger than anticipated. Three-month averages of minimum temperatures (December 1975 through February 1976) reveal a range from 13.3°F at KSTP to 11.4°F at the NWS airport station, to 4.1°F at Anoka, a small community northwest of the cities (Figure 4). Bethel, Minnesota, the station furthest north of the cities, which was activated part-way through this period, was even colder. On a clear, calm winter night with snow cover, 25°F or more ranges in temperature, as shown in Figure 5, are not all that unusual. In this particular case, 17 January 1976, the KSTP low was -3°F, the NWS reported -14°F, but Bethel, Minnesota dropped to -30°F. On the morning of 9 January 1977, in the midst of the great January 1977 cold wave, the minimum temperature at Fridley, the first suburb north of Minneapolis, reported "only" -24°F, with the NWS reporting a record of -32°F, but with many reports far lower than that in outlying areas, including a -55°F at Osceola, Wisconsin (Figure 6). The -33°F temperature difference to the region, while the greatest noted to date, has been frequently approached on many winter nights. KSTP forecasts usually mention at least a 10°F spread in low temperatures within the immediate viewing area, and viewers are no longer surprised to see a spread of even greater than 20° predicted. Table 1 summarizes differences in the coldest monthly temperature and number of sub-zero minimums between the NWS and any station in the network for eight winter months.

The Twin Cities urban heat island appears to be very strong indeed. Data obtained from the instrument tower at KSTP, virtually in the heart of the urban area, show that on clear, calm cold mornings a shallow neutral or super-adiabatic layer is present close to the ground with an intense overlying inversion beginning several hundred feet above. Evidence suggests that there is indeed convergence of the surface winds to the center of the urban area on these mornings. This

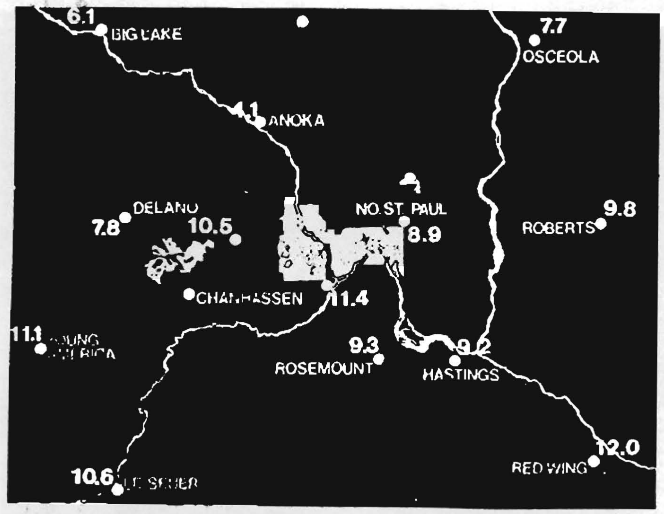

Figure 4. Average minimum temperatures December 1975 through February 1976 at selected sites in Twin Cities Metropolitan area. Map shown is 69 x 77 miles (110 x 123 km) in size. The cities of Minneapolis and St. Paul are shown in a light tone.

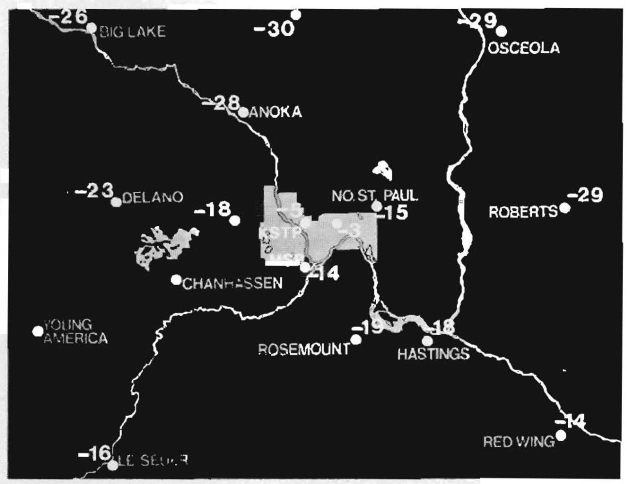

Figure 5. Minimum temperatures observed on morning of 17 January 1976 showing classic heat island.

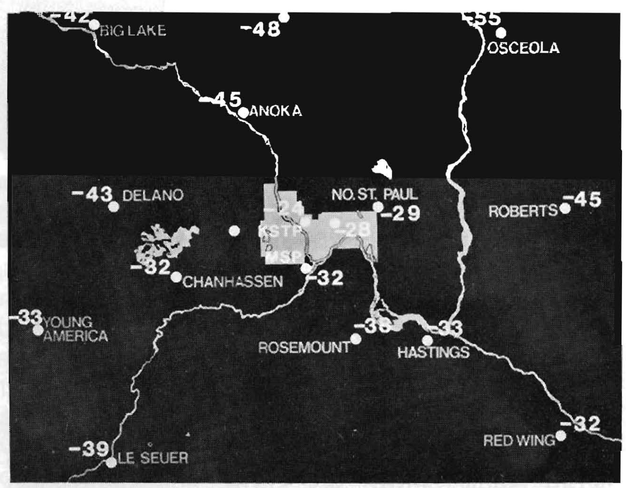

Figure 6. Minimum temperatures observed on morning of 9 January 1977, during the worst of the Great January 1977 Cold Wave in Minnesota.

can often be noted by the accumulation of fog, steam, and aerosols over the cities, often with clearly visible internal waves at the inversion surface overhead (Figure 7).

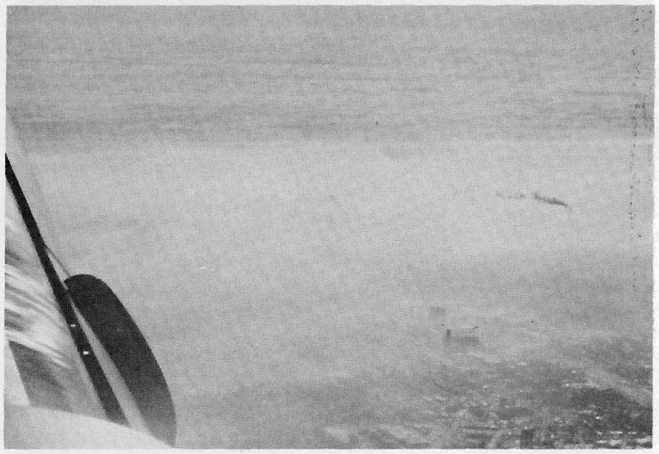

Figure 7. Mixture of fog, steam and particulate air pollution over downtown St. Paul, Minnesota shortly after sunrise on a typical winter morning during "heat island" conditions.

only 1/2" in the southwestern portion of the viewing area, but was greater than 5" north to northeast of the cities. Drivers concerned with road conditions find this data extremely useful. Also, a forecaster knowing regional variations in temperatures with the thermometer hovering around the melting point, can give better estimates of where ice and snow may be lingering on the roads after a snowfall. The total snowfall from December 1975 through April 1976 is shown in Figure 10. The NWS reported 38", but only 8" fell at Le Sueur to the southwest, while 48" fell at Osceola, Wisconsin in the northeast. Such variability in snowfall has significant effect on frost penetration in the soil, and in predictions of spring melt and run-off. Figure 10 also reveals how the 1976 drought, which was most intense over southwestern Minnesota, was aggravated by a lack of snow cover during the preceeding winter.

Forecasts of the first and last frosts of the growing season are of great interest to farmers and home vegetable growers. A study presented by Baker and Strub (1963) showed a strong

TABLE 1. COLD WEATHER STATISTICS COMPARING "OFFICIAL" NWS REPORT AND KSTP OBSERVER NETWORK EXTREME

	1976					1977		
	JAN	FEB	MAR	NOV	DEC	JAN	FEB	MAR
NWS Minimum	-18	-11	- 3	- 6	-23	-32	-11	+ 8
Coldest in Network	-30	-28	-14	-23	-38	-55	-28	- 4
NWS Sub-Zero Minimums	14	5	2	3	15	26	3	0
Greatest Sub-Zero Minimums	21	7	6	4	21	27	10	2

As would be expected observed high temperatures do not show anywhere near the variability of the minimums. Yet this still leaves a surprisingly large annual range in temperatures to be found within the immediate metropolitan area. By taking the difference between the observed minimum and maximum temperatures recorded from 1 July 1976 through January 1977, Figure 8 shows a range of 121°F to 155°F in the outlying colder locales. This type of variability should be recognized by heating engineers and others making temperature dependent calculations.

The availability of precipitation reports, especially snowfall, on a near-real time basis, is invaluable to the television weathercaster. The snowstorm situation on 1 March 1976 (Figure 9) illustrates a typical case. While the NWS airport station reported a fall of 2.7", it dropped off to

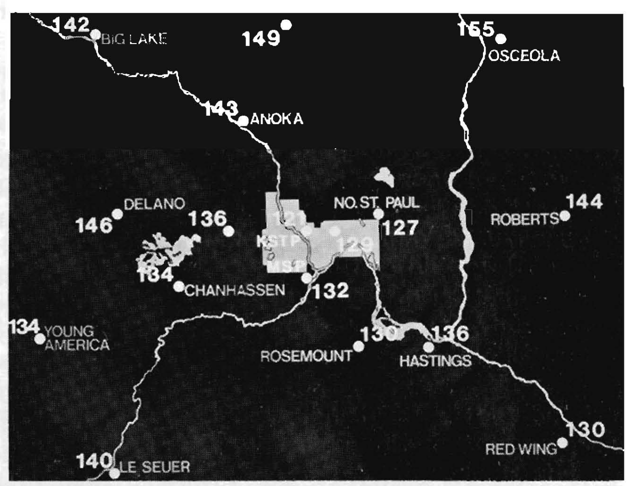

Figure 8. Total range in observed temperatures ($^{\circ}$F) during period July 1976 to January 1977.

gradient in these dates in the metropolitan area and the KSTP Observer Network confirms this. For instance, the date of the first freeze in autumn 1976 (Figure 11) varied from as early as September 21st in the low-lying northern areas, to as late as October 6th in the city and around the Lake Minnetonka area west of the cities, as well as along the Mississippi River valley. This 1-3 week variability of first and last frosts surprises many a vegetable grower who is relying on forecasts and climatology based solely on airport observations. Careful attention to the Observer Network also allows the forecaster to predict such phenomena with a fair degree of accuracy. One spring night in 1977, a frost threatened to wipe out early plantings. A forecast was made of minimum temperatures for each of the 24 stations, which ranged from 23 to 39°F. These were displayed in map form on the television and thus persons, by noting where they lived, could take proper precautionary procedures to protect their young plants. Verification on the next day showed an average error to be +1.1°F.

During August 1977, the KSTP WSR-74c radar system was upgraded to a digital color display showing precipitation intensities in six distinct colors. A video discassette system allows storage of up to 200 frames for instant animation and playback of rain patterns as they move across the area. On the night of 30 August, heavy rains began during the 6:00 p.m. telecast. By 9:00 p.m. the color animation display strongly suggested intense rainstorms were remaining nearly stationary over much of Minneapolis and St. Paul. A Flash Flood situation was clearly developing. Once again observers called with updated reports, proving their worth by supplying confirming rain reports. By the 10:00 p.m. telecast, the gravity of the situation was apparent, and TV, AM and FM emergency weathercasts disseminated this information to the public in close cooperation with the National Weather Service. In four hours rainfall varied from nearly 9" just west of Minneapolis to less the 0.5" at Le Sueur. Millions of dollars in damage occurred, yet no lives were lost. It is felt that accurate mesoscale nowcasts from all concerned parties helped prevent loss of life.

There has been enthusiastic public response to telling the weather like it is - spatially and temporally variable. Viewers now feel they can get a better feel for what the weather is at their house, not at some distant airport or television station. As society becomes more technologically oriented, our dependence upon environmental factors will rise, not fall. The KSTP Observer Network, while not unique in this country, but when combined with high resolution satellite and radar imagery, is a public demonstration of the meteorological wave of the future - real time nowcasting to meet the growing public needs for weather data and forecasts.

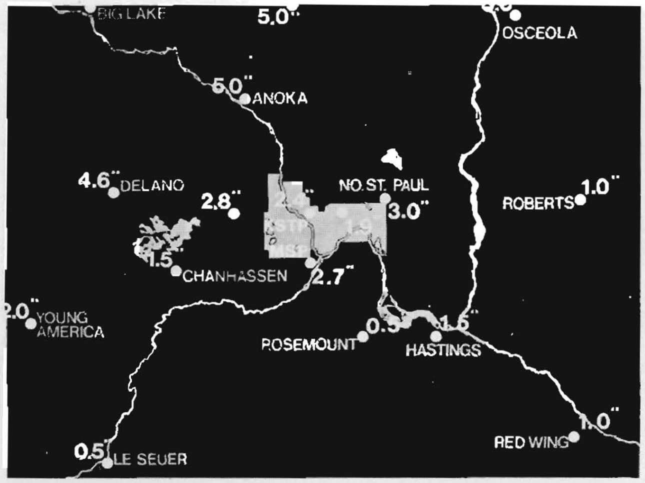

Figure 9. Snowfall, 24 hours ending 5:00 p.m. 1 March 1976, over Twin Cities Metropolitan area.

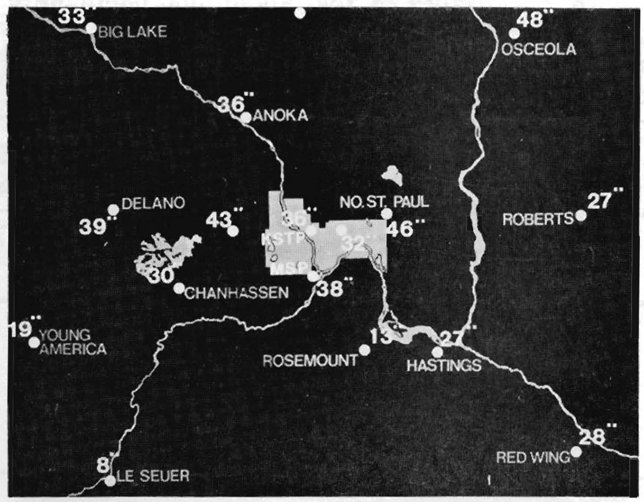

Figure 10. Total snowfall, winter of 1975-76 (excluding November 1975) over Twin Cities Metropolitan area.

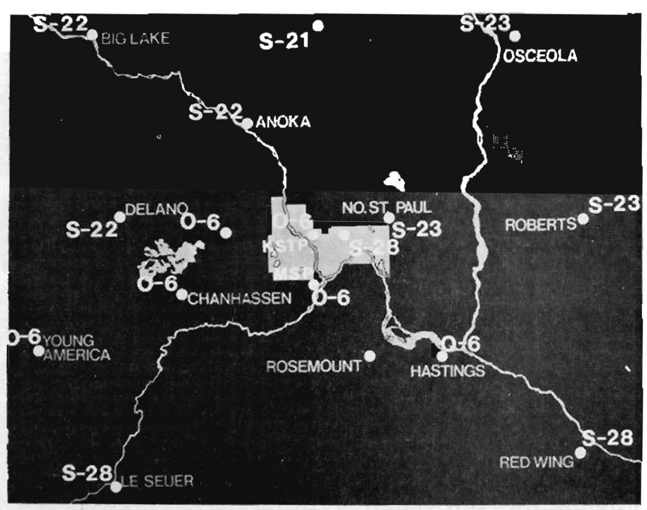

Figure 11. Dates of first hard freeze (0°C or below) in autumn of 1976).

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National Weather Digest

VERTICAL WIND PROFILE CHANGES REVEALED BY SATELLITE OBSERVATION OF A VOLCANIC PLUME

by

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1. INTRODUCTION

During the period 4-8 February 1978 an interesting combination of meteorological and geological events provided some spectacular scenery as viewed from the polar-orbiting NOAA-5 satellite. The variable configuration of a volcanic plume indicated changes in the vertical wind structure west of a maturing extratropical cyclone. The imagery also furnished valuable guidance concerning an inflight hazard not likely to face aviation forecasters in most of the Lower 48.

II. METEOROLOGICAL AND GEOLOGICAL SETTING

A deep mid- and upper-level trough developed over western Alaska on 4 February and moved slowly eastward for the next several days. The 1200 GMT 50 kPa and 85 kPa charts for 6 and 8 February (Figures 1 (a) - (d)) depict the general sequence of events and correspond approximately in time to satellite imagery that follows. Intense surface cyclogenesis in the northern Gulf of Alaska accompanied the sharpening trough aloft. Fueled by a temperature gradient featuring surface readings from -46°F over northwest Alaska to +4°C in the Yukon Territory, the storm produced hurricane-force winds that swept across some southern coastal sections. The gradual eastward translation of the system resulted in an extended period of snow in southcentral Alaska. The five day storm total at Anchorage was 52.8 cm.

As the low deepened, very cold air was drawn southward from the Arctic. The NOAA-5 infrared image in Figure 2, taken from approximately 1450 km, clearly shows the numerous convective cloud streets formed as the cold air advected across the relatively warm water. South of the Alaska Peninsula, several streets assumed visual similarity to laboratory-produced von Karman vortices. (An excellent treatment of wake vortices in the lee of the Aleutians is provided by Thomson *et.al.* (1977.)