OPPORTUNITIES AND PROBLEMS IN THE AUTOMATION OF SURFACE WEATHER OBSERVATIONS

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With the advent of inexpensive microprocessors and continuing rapid advancement in high speed communications, it seems the time is ripe for the complete automation of surface weather observations. Consider the dream: instant knowledge of current weather conditions anywhere observations are taken...special observations instantly whenever the weather changes by a specified amount...all of this done with extreme accuracy and high reliability by state-of-the-art sensors without the high costs that come with a labor-intensive activity.

Because the dream is so attractive, there is a great and understandable temptation to rush to make it real. Many of the easy problems have been solved. Electronic devices can be polled as often as desired. Such elements as temperature, pressure and wind velocity can be reliably measured and collected without human intervention. The ceiling and visibility can also be determined, even from sites not accessible to the human observer. Rain can be measured as often as necessary. In fact, an argument can be made that all the weather elements that are operationally significant for aviation interests can be collected and disseminated automatically with today's technology...and some of tomorrow's money.

Traditionally, observations have been collected in this country by the Federal Aviation Administration, the National Weather Service and the Armed Forces. While the hourly data are primarily geared to aviation uses, all weather forecasters have relied on the existing network of observations and methods of taking and sending them because that is all there has been. As long as the current system remained in place, only relatively minor changes could reasonably be expected. Forecasters might wish for additional types of data and more observation points, but many of these proposals were simply too costly.

Now, however, we may be witnessing what turns out to be a complete revolution in weather observations...from human to machine. My purpose here is not to argue for or against either observer. Forget for a moment the value of a person with weather knowledge in each of hundreds of communities across the land. Ignore for a moment the value to a pilot of talking with a person at a nearby airport who might be in a position to provide a little extra advice at a difficult time. Never mind that we might be replacing an army of weather observers with an army of electronic repair technicians. Whatever we do, the system must take the observations correctly and be reliable.

Let's not forget that now may be the best time we will have as operational meteorologists to insist upon and obtain the data we want and need to do our work to greatest advantage. Now, at the very time when all the equipment and methodology are under design, is when we should come forward and insure that the systems of the future will give us the tools we need. The specialists in instrumentation are not necessarily versed in weather forecasting and cannot automatically be expected to know about all the problems forecasters face. Perhaps it is time to recommend task forces made up of private and public sector forecasters, and the instrumentation, computer, and communications specialists to oversee the development of new observational systems. Once new systems are bought and put in place, it will be too late.

Now, what are some of the things we should insist upon? First, this depends on the intended uses of the information. Different types of forecasts require different input. To land a plane, it may be sufficient to know that you have "400 and 1." But...why is the visibility 1 mile? If snow and fog are present, which is the greatest contributor to visibility reduction? In the absence of fog or blowing and drifting snow, it is possible to make a good estimate of snowfall rate from the visibility. But...if there is fog or some other obstruction other than snow cutting down the visibility, the issue is, you might say, obscured.

Several years ago, very light precipitation--generally too light to measure regardless of its duration--was denoted by the double minus following the letter telling us the type of precipitation. Very light snow was S--. This category was eliminated, despite objections from some meteorologists. Now many observers add, on an optional basis, the remarks "precipitation very light" at the end of the observations when precipitation falls in this category. While this is helpful, it makes observations non-uniform, and where the practice is not followed we have lost an element of information we previously had. Also, it takes much longer to spell out the remark than to print a minus.

For the aviator, it may not be absolutely essential to know the precise intensity of precipitation. However, the United States spends more than 3 billion dollars annually clearing snow and ice. Losses from snow and ice storms run to many more billions of dollars. Many cities, states and industries rely on private sector forecast companies for management consulting services during winter storm situations. In one relatively small eastern state, it costs 40,000 dollars an hour to fight a winter storm, so the advice we give can create huge savings or compound the costs. Trucking companies, the bus lines, and motorists all need to know if there are weather hazards. Safety and money are on the line. But how can the forecaster estimate the risk properly if he doesn't know the intensity of precipitation? Radar is of limited usefulness in snowstorms and satellite pictures are limited in use as well. Not only must intensity be known, the type of precipitation must be known accurately. Freezing rain weighs down power lines and trees while transforming highways into crashup derby arenas. Sleet, while occurring in similar weather situations, produces different effects. Aside from hail, it is the only type of frozen or freezing precipitation that can produce slippery roads when surface temperatures are above freezing. It does not accumulate on power lines, but takes much longer to melt than the same depth of snow. Wet snow has different characteristics than dry snow, and when a combination of precipitation types occur simultaneously, the effects are even more varied. Herein lies a great challenge to any automated system: we need this knowledge. Can the precipitation types and their respective intensities always and without fail be distinguished? In harsh subfreezing environments, will changes in precipitation type be observed, or will capability be limited by equipment that gets covered or iced by the very precipitation under observation?

I am not an expert in the design of instrumentation. But, it does seem reasonable to expect it will take some ingenious devices to satisfy all the problems. If implementation of systems goes forward without solving them, we will have taken a huge step backward in our ability to make good forecasts. Operational meteorological forecasting rests on a foundation of good weather observations. Take them away and the credibility of the profession will suffer. (As if we needed anything else!)

Other problems come to mind. If wet snow is falling, how will this be distinguished from rain if it melts on the sensors? How will drifting be accounted for? How much snow and ice can fall without rendering the collection device inoperative? What happens if a device fails? Will some melting apparatus be needed? Or, can the different forms of precipitation be distinguished optically? If sleet, freezing rain, fog, and snow are present simultaneously and the precipitation types change frequently, will the instrumentation be sensitive to all the changes? The importance here is that these mixed precipitation situations cause plenty of consternation in the forecast office. The locations of many of the nation's most populous cities with respect to oceans or mountains often place them near the rain-snow boundary. Forecasters need all the clues they can get when critical situations arise.

For measuring snowfall, I would recommend the amounts be measured hourly. This would be a tremendous stride in all snowstorms. Decisions involving many people and millions of dollars are being made on the basis of our forecasts.

Let's look at some other observational problems. How cloudy is it, and how do we know? Satellite photos help greatly with this. However, many forecasts still bust when the forecaster at a remote site incorrectly estimates the thickness of the clouds. Is the sun visible? Is it casting shadows? Is the cloud cover thickening or thinning? What about building cumulus or developing stratus? Cumulus won't show on radar, but a thunderstorm may be minutes away from developing. The current human comments: Moon dimly visible during a snowstorm...Towering cumulus on a summer afternoon...Virga ALQDS as a vorticity max approaches...Funnel cloud reported by public...All these and more may be difficult to replace in automated observations.

The dewpoint is a critical element of observations. H. Stuart Muench of the Air Force Geophysics Laboratory at Hanscom Air Force Base in Massachusetts reported in the October 1980 issue of the NWA Newsletter a problem with summer dewpoint measurements along the Eastern Seaboard. He points out that the electronic instrument now in use requires careful calibration. If the dewpoint cannot be measured correctly, the notion of doing more sophisticated automation may be all wet.

Eric Mandel reported on some of the proposals being studied in the automation field (2). One idea is to report only those clouds that are at or below 10,000 feet. This would leave a serious hole in the observations. Satellites would help, but if there is a high deck of cirrus, we might never know about an altostratus deck sneaking in at 12,000 feet. In winter, when the temperature is near freezing, it may take only a little sunshine to send temperatures above freezing and thus avert snow and ice problems. But if we only know about the clouds below 10,000 feet, we will have a much more difficult time determining how much sunshine to expect. Perhaps a new automated device could be installed to measure brightness. We could even envision a brightness indicator that is calibrated for latitude and time of year plus any other optical consideration so that we can really determine how much solar radiation is coming through. What about the routine use of pyrheliometers?

What is the common thread running through all of this? It is simple. We want to make better weather forecasts. We want to be able to make accurate weather forecasts for all weather-sensitive users. As the price of everything goes up, anything we can save through better weather information becomes more and more important.

Field forecasters have long recognized the importance and usefulness of a dense network of surface observations in making reliable weather forecasts. The scientists involved in the PROFS (Prototype Regional Observing and Forecasting Service) program have recognized the importance of mesoscale events. Many forecasters yearn to improve our forecasts for the next 6 hours. Millions of dollars have been and will be spent on improved computer models to better predict the changes that slip through the grids of the coarser models. All of this begs for more and better surface observations of as many parameters as possible, as often as possible.

It is time to recognize also the fact that aviation is not the only use to which observations are put. True, the Federal Aviation Administration must cater to aviation. It is to that and other agencies' credit that observations are as good as they are.

But when we talk about the needs of tomorrow's observational program...when we think of the uses to which accurate weather observations and forecasts will be put...we recognize that the issue goes far beyond aviation. Perhaps the FAA and the other agencies involved will be able to come up with a package that satisfies all the needs. But perhaps others should be brought in. What about agriculture and transportation interests? And shouldn't operational forecasters, public and private, have an important say in what is done?

We need the best observations money can buy. We have a great opportunity to get significant improvement as advanced technology makes formerly expensive operations routine and economical. Those responsible for implementation of new systems will have to recognize the vast opportunity they have, and we as operational meteorologists will have to watch and help as much as we can. For what is at stake here is the very future of our profession. We can have the best communications and the best computer forecasts. We can have good forecasters, satellite pictures and all the rest. But if the quality of our surface observations suffers a setback, we all suffer. Automation of surface weather observations sounds great, but let's make sure it is done right. Failure to do this could jeopardize the work we do and lower the esteem of the entire profession.

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REFERENCES AND FOOTNOTES

1. Elliot Abrams received his M.S. in Meteorology from Pennsylvania State University in 1971, and served as a chief forecaster in the Ohio Air National Guard in the early 70's. He began his career with Accu-Weather, Inc., a private meteorological firm in 1967, where he now serves as a Senior Vice President.

2. Mandel, Eric, 1975: "Early Look at the Development of an Unmanned Automated Surface Aviation Weather Observation System", Bulletin, AMS, 56 (9): 979-982.