Wind Measurement and Archival under the Automated Surface Observing System (ASOS): User Concerns and Opportunity for Improvement

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Abstract

The National Weather Service, as a part of its modernization effort, is implementing the Automated Surface Observing System (ASOS). Much discussion has occurred about various aspects of ASOS versus the current system of manual and automated observations. Based upon a study of the ASOS specifications and an informal survey of potential ASOS winddata users, defects of the wind sampling and archival strategy chosen for ASOS are discussed in terms of their impact on various user groups. Limitations include: 1) hourly observation average periods that do not conform to international recommendations for wind reporting made by the World Meteorological Organization, 2) no regular archival of high-resolution data—potentially valuable research data are destroyed if not identified within a 12-h period, and 3) no emergency power for operation in severe weather conditions. An alternative sampling and archiving strategy is recommended that benefits a wider cross section of users, without detracting from aviation and forecast service requirements, at a cost of less than 1% of the original ASOS portion of the weather service modernization budget.

1. Introduction

The National Weather Service (NWS) is modernizing its instrumentation and restructuring its organization. As part of this process, the NWS, with the Federal Aviation Administration (FAA) and the Department of Defense (DOD), will install ASOS at more than 1000 airports in the United States. Over the next five years, ASOS will replace nearly all manual surface aviation observing programs. Because the FAA, NWS, and DOD will fund the majority of the ASOS sites, they determined the wind-sampling requirements that will affect many potential user groups. The author conducted an informal survey of representatives from several user groups that revealed serious concerns about the wind-sampling strategy and archival methods chosen for ASOS. Among these concerns are hourly wind observations that do not conform to international recommendations for averaging period, short averaging periods representative of small-scale motion rather than larger-scale motions that have predictability, and lack of automatic archival of high-resolution data required for research. The results of this survey, together with the author's own viewpoints, are summarized in the following sections.

The purpose of this paper is to discuss limitations of the ASOS wind-sampling strategy in view of well-known characteristics of wind variability, international standards for wind measurement, and needs of the user community. We present an alternative strategy for ASOS wind data sampling and archiving that consists mainly of software changes and appears to satisfy most user concerns without detracting from the primary historical function of service to the aviation community.

2. Wind variability

The design of an adequate sampling strategy depends upon knowledge of the variability of the quantity to be measured. Winds have fluctuations on temporal scales ranging from interannual to tenths of a second, associated with spatial processes occurring over synoptic, meso-, convective, turbulent, and finally, viscous scales. This point is illustrated by wind speed spectra, such as those by Van der Hoven (1957), Fieldler and Panofsky (1970), Smedman-Hogstrom and Hogstrom (1975), Panofsky and Dutton (1984), Pierson (1983), and Champagne-Philippe (1989).

For example, Fig. 1 from Champagne-Philippe (1989) shows spectral density computed from 12 h of consecutive 3-s average wind data from 10-m masts on the shore of Baie d' Audierne, France, during the TOSCANE T experiment. The mean wind for this case (22) was onshore at 10.7 m s^{-1}. The spectrum is plotted so that the area under the curve, over any frequency band, is proportional to the variance in wind

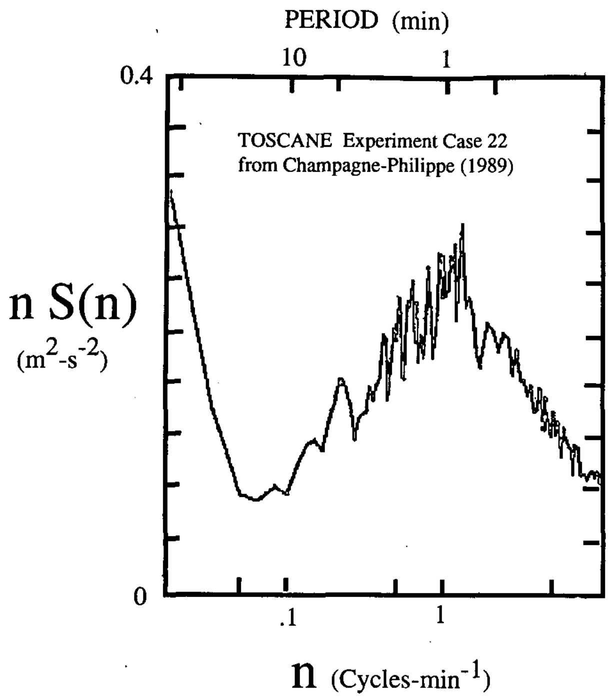

FIG. 1. Spectrum of the streamwise horizontal (u) component of the wind velocity [from Champagne-Philippe (1989)] for a 12-h period during case 22 of the TOSCANE experiment. Mean flow is onshore at 10.7 m s^{-1}. The y axis is expressed as the product of frequency, n, and spectral energy density, $S(n)$, and had units of variance.

speed. The low-frequency peak is due to fluctuations with periods of several hours. These fluctuations are caused by the effect of synoptic-scale and mesoscale weather systems with time scales greater than 1 h. The high-frequency peak near 1 min is due to turbulent fluctuations and, perhaps, convective-scale effects from individual clouds with periods of seconds to a couple of minutes. Measurements from inland sites would contain more variance at the turbulent microscales relative to this case for onshore flow.

A scale separation is indicated by the relative minimum in variance or "spectral gap" at frequencies corresponding to time periods of 10–100 min, between the low-frequency synoptic scale and the high-frequency turbulent scale. Pierson (1983) suggests that the gap moves to lower frequencies and the high-frequency variance increases as the wind speed increases. Champagne-Philippe (1989) presented evidence suggesting that the spectral gap is prevalent except during episodes of open cellular mesoscale convection. Wind measurements with averaging periods corresponding to the spectral gap are unaffected by small-scale, turbulent fluctuations as discussed by Panofsky and Brier (1965):

> The question may be raised over what interval of time winds should be averaged in order to be stable. It is common practice to average winds over one or two minutes. Now, it turns out that the spectrum of the wind variance has a great deal of energy near periods of two to three minutes, implying gusts every two to three minutes. This means that a 1 min wind now and a 1 min average a minute later may come out quite differently. In fact it appears that winds near the surface should be averaged for at least 30 min before really stable estimates can be expected.

Additional recommendations of averaging times for surface wind observations include 4 min (Sparks and Keddie 1971), 20 min (Pierson 1983), and 1 h (Panofsky and Dutton 1984). The ability of wind measurements (averaged over time periods within the spectral gap) to resolve mesoscale or synoptic-scale wind features will depend upon the frequency of measurement, the density of observing sites, and the filtering properties of the analysis system.

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3. ASOS wind sampling and archival strategy

According to the draft ASOS Users Guide (ASOS Program Office Staff 1991), the sampling strategy chosen for ASOS consists of 1 s^{-1} measurements of wind speed and direction from which 5-s means are computed. The reported winds consist of 2-min averages computed from the 5-s means and the peak 5-s mean (gust) over the 2-min averaging period. The maximum wind speed capable of measurement by ASOS is 65 m s^{-1}. The 2-min means and gusts are computed at overlapping 1-min intervals (each 2-min mean contains 1 min of data from the previous 2-min mean). These data are stored on site at 1-min intervals for 12 h; they may then be downloaded by a carefully controlled set of users via modem—if not downloaded for archival, the data are overwritten and destroyed. In the event of a power outage, no backup power capability exists; data recorded up to the time of data loss are maintained in nonvolatile memory until power is reestablished.

The hourly observation for operational purposes is the last 2-min wind measurement before the hour.

Also included in the observation is the occurrence of wind squalls (>15-kt wind increase in <2 min, with a sustained 2-min speed of >20 kt), peak winds (the greatest gust over the past hour that was >25 kt), special wind alerts (wind speed is >25 kt and the current 2-min wind is a factor of 2 or more greater than the previous wind), wind shifts, and variable wind directions. Special alerts can be issued or remarks appended to the hourly observations when these conditions are satisfied.

For climatological purposes, a daily summary is transmitted at 0000 local time, including the daily average wind speed, fastest 2-min average, and peak wind for the day. The daily average is the mean of the 24 hourly, 2-min observations. The daily summary data, together with the transmitted hourly and special wind observations, are stored for 31 days in the ASOS site database and archived at the National Climatic Data Center (NCDC).

4. Internationally recommended standards for wind measurement

The World Meteorological Organization (WMO) recommends a 10-min wind average for synoptic observations from automated weather stations, from ships fitted with anemometers, and for observations transmitted from aeronautical stations (WMO 1988). WMO (1988) recommends 2-min wind averaging periods only "for reports used at the aerodrome for takeoff and landing and for wind indicators in air traffic services units." According to the WMO (Ken McLeod 1990, personal communication), only the United States (with 1-min observations), Canada, and the former USSR (both with 2-min observations) do not adhere to the WMO recommendation. The *Federal Meteorological Handbook, Surface Synoptic Codes* (Office of the Federal Coordinator for Meteorological Services and Supporting Research 1988) also states that the mean true direction and speed of the wind will be determined during a 10-min period.

5. Real-time and retrospective wind data usage and requirements

Surface airways observations (SAOs) have surpassed their historical function of support for aircraft operations. High-quality, high-resolution wind measurements are crucial for monitoring the earth system. In addition to aviation support and operational forecasting, many other disciplines in atmospheric and environmental sciences, engineering, transportation, and commerce rely on SAO wind data that are collected in real time or are available from climatic databases. It is not clear whether these user groups were consulted to determine their wind data requirements under ASOS. The concerns for these applications are elaborated below. These, and user groups not represented here, such as hydrology, agriculture, wind energy, and fire weather, may have additional concerns and requirements that should be considered.

a. Operational forecasting of severe weather

To identify, track, and predict severe weather associated with mesoscale circulations, forecasters must have wind observations that represent the time and space scales of the disturbed weather. As depicted in the reconstructed wind trace for the Charleston NWS Office during Hurricane Hugo (1989) in Fig. 2, longer-period wind averages are less sensitive to turbulent fluctuations. In addition, oceanic wind fields based on 10-min mean winds are more representative of the scales producing surface stress forcing for initialization of storm surge and wave forecast models.

More frequent wind reports are useful in defining mesoscale circulations. The importance of higher-frequency wind reports in resolving the wind field of Hurricane Bob (1991) is demonstrated in Figs. 3a–c. Hourly winds (2-min average) are plotted (Fig. 3a) in a storm-relative coordinate system for the period corresponding to Bob's passage over the Diamond Shoals Coastal Marine Automated Network (CMAN) platform. The improvement of the wind data distribution after replacement by consecutive 10-min mean data from Diamond Shoals and the other CMAN sites is shown in Fig. 3b; the maximum winds on each side of the eyewall are resolved and data coverage is similar to that produced by reconnaissance aircraft in Fig. 3c. The National Data Buoy Center (NDBC) is now considering making consecutive 10-min wind data available in real time.

The 45th Interdepartmental Hurricane Conference (Carnahan 1991) endorsed the following recommendations for wind-sampling strategies by automated weather stations as serving the interests of the hurricane operational and research communities.

1) Adopt WMO 10-min average at the 10-m level for hourly observations.

2) Record consecutive 1-min averages from 5-s block averages and archive these data at NCDC.

3) Transmit peak 1-min and peak 5-s average winds over the past hour with hourly observations.

4) Have the ability to interrogate a 10-min average, peak 1-min average, and peak 5-s average every 10 min under specified criteria.

The peak 5-s and 1-min winds would provide information required for warnings; such data are especially

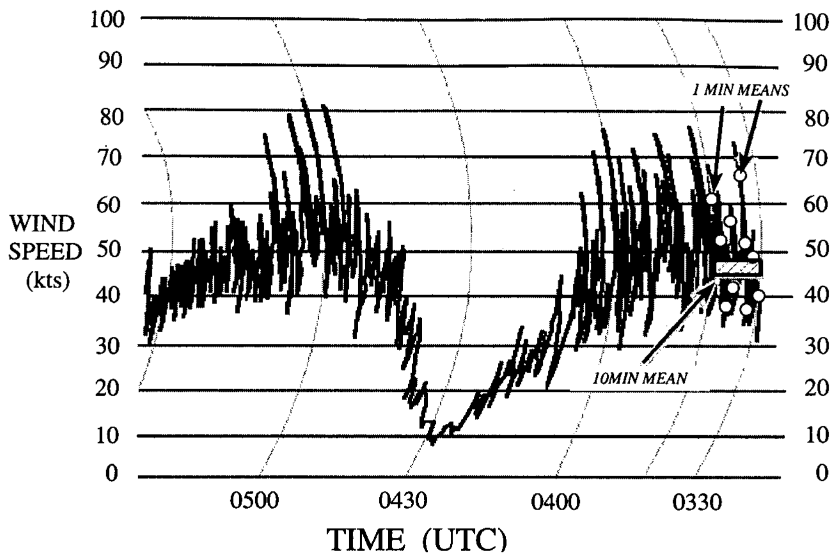


FIG 2. Reconstructed wind trace from the Charleston, South Carolina, NWS office during Hurricane Hugo, 21–22 September 1989. Times are UTC, speeds are presented in units of the original trace (kt) (from Powell et al. 1991).

provided at 10-min intervals, would better represent mesoscale circulation features.

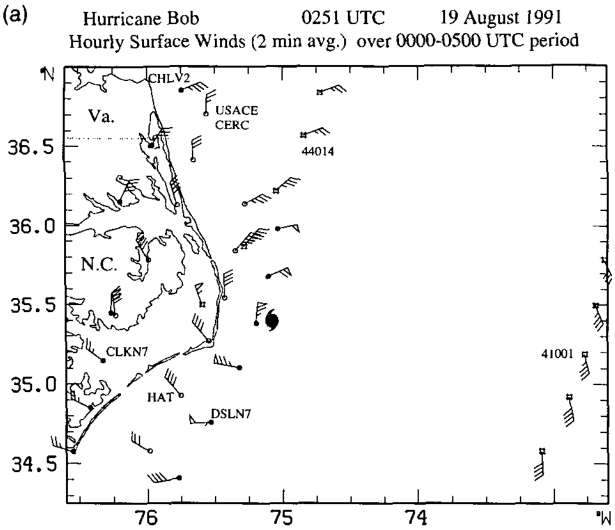
Some meteorologists perceive that a given 10-min mean hourly wind speed observation will always be lower than a 2-min mean hourly. One can ascertain from Fig. 1 that at any particular time, because of high variance at periods near 2 min, a 2-min mean may be higher or lower than a 10-min mean. This point is further illustrated by a comparison of winds sampled 2 min (2-min mean) and 10 min (10-min mean) before the hour from 143 observations from eight CMAN platforms in Hurricanes Hugo and Jerry (1989), Tropical Storm Marco (1990), and Hurricane Bob (1991). These data (Fig. 4) indicate that variability of the 2-min hourly wind is such that it is equally likely to be larger or smaller (both 48%) than the 10-min wind speed. In fact, 47% of the 2-min mean hourly winds (not shown) were actually lower in magnitude than the CMAN 1-h average wind speeds.

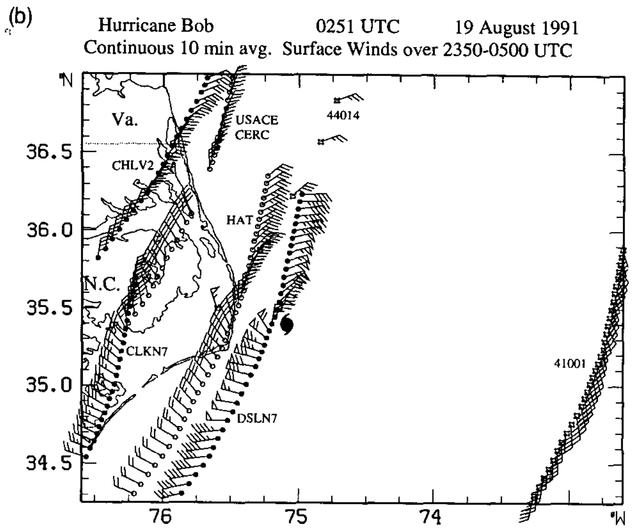
needed for hurricane operations, since the hurricane is defined on the basis of a maximum 1-min mean wind speed. For severe weather conditions associated with hurricanes, supercells, and other strong wind producers, it is imperative that the wind equipment be capable of both surviving and measuring extreme conditions. This requires an emergency power source. The measuring equipment should be capable of measuring extreme winds caused by hurricanes [e.g., a maximum gust measurement of 77 m s^{-1} in Hurricane Camille of 1969 (Bradbury 1971)] and microbursts in thunderstorms [e.g., 67 m s^{-1} at Andrews Air Force Base on 1 August 1983 (Fujita 1985)]. To ensure a complete severe weather climatology, wind sensors should be capable of measuring wind speeds up to 80 m s^{-1}, rather than the 65 m s^{-1} maximum in the current design.

Identification, analysis, and forecasting of fast-moving, midlatitude mesoscale circulations and their wind fields could benefit from observations in the format specified above. Research field programs could also benefit from more frequent wind reports as attested by ASOS support for the Stormscale Operational and Research Meteorology Fronts Experimental Systems Test (STORMFEST) (STORM Project Office 1992) during February and March 1992. In the second half of the 1990s, the Advanced Weather Interactive Processing System (AWIPS) (NOAA 1990) will provide 2-min mean winds at 5- or 15-min intervals upon forecaster designation of warning or alert mode. A 10-min mean wind with peak 5-s gust and peak 1-min mean,

b. Numerical weather prediction and data assimilation

Dey (1989) and Peterson et al. (1991) pointed out that the ASOS system, in combination with profilers, WSR-88 Doppler radars, and automated aircraft observations, promises to improve coverage and frequency of observation over the United States. These data sources have prompted the National Meteorological Center (NMC) to investigate a regional data assimilation system capable of ingesting data as often as every hour. Although marine and land surface observations are included in the regional analysis and forecast system (Hoke et al. 1989), only marine surface winds are considered. According to Hoke et al. (1989), surface winds over land are excluded due to small-scale mountain effects and possible incompatibilities with a geostropic constraint in the analysis. With more sophisticated physics and finer grids, regional and mesoscale models (e.g., Stauffer et al. 1991) will soon be able to take advantage of hourly or even 10-min-frequency surface wind data over land and sea. These upcoming developments bring additional concern about the representativeness of a 1- or 2-min wind average. Longer averaging periods for land-based surface winds will improve covariance statistics with surrounding stations (Wylie et al. 1985) and remove much of the small-scale variability associated with turbulent and convective wind fluctuations.





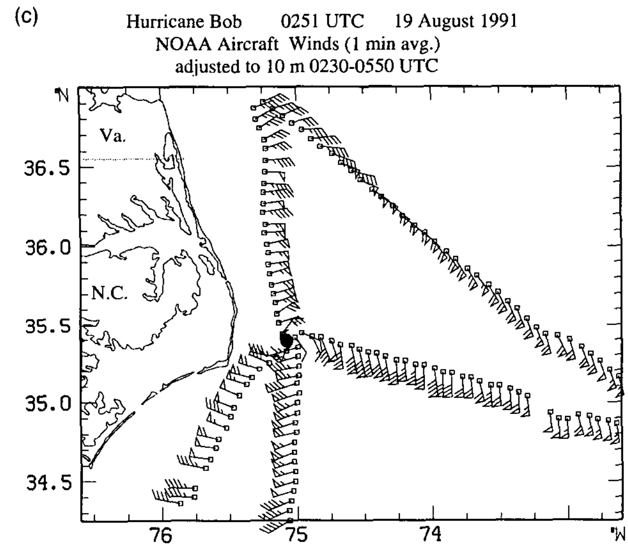


FIG. 3. Comparison of Hurricane Bob wind data distributions in a storm-relative coordinate system for (a) hourly, 2-min average measurements from CMAN platforms (filled circles), moored buoys (open squares), and coastal stations (open circles) at (diagonally from upper left to lower right) Chesapeake Light (CHLV2), U.S. Army Corps of Engineers Coastal Engineering Research Center (USACE CERC) at Duck, NC, Cape Lookout (CLKN7), Cape Hatteras (HAT), buoy 44014, Diamond Shoals (DSLN7), and buoy 41001. All observations are adjusted to 10 m, geography is positioned for storm location at 0251 UTC; surface data are from 0000–0500 UTC 19 August 1991. (b) As in (a), but consecutive, 10-min average measurements, from stations so equipped, from 2350–0550 UTC, and (c) as in (a), but NOAA aircraft reconnaissance observations from 0230–0529 UTC, 1500-m flight-level data were adjusted to 10 m with a PBL model.

Spectral analysis of ASOS wind data is recommended to identify high-frequency scales of motion that are not capable of being resolved by the next generation of mesoscale models.

An additional problem concerns the use of surface wind data made available through the Global Telecommunication System (GTS), and thereby available for assimilation in other countries. Surface wind input data for numerical forecast models should conform to an internationally established standard: the WMO-recommended 10-min mean. For more accurate inclusion into data assimilation systems, especially for mesoscale models, the surface wind observation time should be corrected to refer to the midpoint of the averaging period.

c. Global climate change monitoring

The same wind data that are available for data assimilation over the GTS also become part of the global climate database. Users of marine wind climate data (e.g., Cardone et al. 1990) are familiar with problems caused by nonstandard observing methods. In fact, the NDBC is considering changing the averaging period of all CMAN and moored buoy platform wind measurements to conform to the 10-min period recommended by the WMO.

The effect of a change in sampling on the climatic record is another concern. Changing from 1-min manual to 2-min ASOS or 10-min WMO measurements may affect the wind climate record at a particular site. If high-resolution ASOS wind speed and direction measurements were made each minute, consisting of the 1-min mean, peak 5-s mean, and standard deviation of the 5-s mean about the 1-min mean, and these data were archived permanently, the 1-min climate record could stay intact. In addition, daily summary data would not have to be sent via long-line transmission at the end of each day, but could be computed, with other climate products, at NCDC after transfer from each ASOS site. Other users could take advantage of the high-resolution data to compute any mean of interest for their particular application, and a complete record

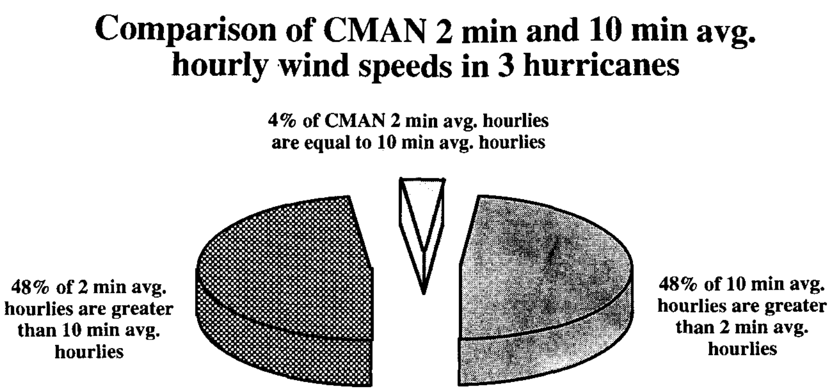


FIG. 4. Comparison of CMAN 2-min hourly winds greater than, equal to, and less than 10-min average winds measured 10 min before the hour in Hurricanes Hugo (1989), Jerry (1989), Bob (1991), and Tropical Storm Marco (1990).

of wind extremes and wind variability would be available for investigations even years after the fact.

With the proliferation of mass storage devices and data-compression methods available today and projected for the future, high-resolution archival should be a realizable objective. The major obstacles to overcome concern on-site archival of high-resolution data after the 12-h storage period is exceeded and the logistics of transferring the data to NCDC without loss. A high-resolution wind archive would be especially useful for research investigations, many of which cannot be identified during the 12-h local data storage period.

Is the additional cost of a high-resolution archive prohibitive? Assuming that 16 ASOS variables are stored each minute, each represented by up to 6 characters, a 12-h storage period of data could be written to a floppy disk twice a day, comprising a daily total of 0.54 megabytes. Once a day, the data on the floppy could be transmitted to NCDC from one of the ASOS acquisition control units (ACU) (if so equipped) or from a personal computer (PC) already available on site. Using currently available V.32bis modems ($300 street price), capable of 4000-character-per-second throughput using V.42bis compression and error checking, a day's worth of high-resolution ASOS data could be transmitted in roughly 2.25 min. If each region's ASOS sites sent their data to NCDC at a prescribed time each day (e.g., if the eastern U.S. region sent their data at 0000 UTC), a maximum of 450 stations would attempt to transmit during the same hour (using automatic redial). If 20 phone lines with V.32bis modems were installed at NCDC, it would take 51 min for each modem to download the data from 23 ASOS sites. Fewer NCDC modems/phone lines would be required if a nationwide transmission schedule was implemented. The cost of the modems alone if bought in bulk (assuming 1304 ASOS plus 20 NCDC at 30% discount) would be roughly $278,000. These modems and phone lines would benefit the user sites by being available for non-ASOS use for most of the day. Floppy-disk media are an almost insignificant cost, since they can be reused after successful data transfer and can be purchased in bulk for $0.25 per disk. Labor involved in transmitting and receiving the data could be minimized by writing scripts or batch files to automate the procedure; backup copies of the data could be made to whatever media the ACU or PC is already using. Installation of 20 new phone lines at NCDC would be approximately $7500 (at Southern Bell rates), with monthly service charges of $720. Daily storage of high-resolution ASOS data at NCDC would total 0.7 gigabytes, which could be stored on digital audio tape (DAT) cassettes and then downloaded to compact disc (CD) for more permanent storage. Hardware for writing to CD costs roughly $10,000 and media costs are less than $10 per CD, for an annual cost of $13,650. These costs will drop further when double-density CDs become available. The ASOS portion of the NWS modernization was initially budgeted at over $38 million for FY 1990–1992 (NOAA 1990); the costs for archiving high-resolution ASOS data, a total of roughly $308,000, are less than 1% of the cost of ASOS.

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d. Environmental monitoring and hazard prediction

Meteorologists who monitor air quality often prepare studies to determine dispersion and diffusion characteristics of sites under varying atmospheric conditions. Environmental Protection Agency (EPA) site demonstration studies (On-site Meteorological Data Work Group 1987) require on-site wind measurements for determination of 1-h averages and standard deviations of speed and direction. Wind data must be collected for a period of 1 year or more; hourly 1-min SAO observations are only adequate for filling small gaps in the on-site record. If an ASOS site were nearby, high-resolution 1-min means and standard deviations of the 5-s mean about the 1-min means could be archived for computation of the 1-h average and standard deviation.

In emergency response episodes, such as the Chernobyl incident or a hazardous release from a train derailment, dispersion models have shown improved performance with real-time wind input (Raes et al. 1991). These models could utilize longer (than 1 or 2 min)-period surface wind averages if supplied in a timely manner. The WMO 10-min average might better fit EPA model input requirements than ASOS 2-min average winds. Alternatively, if high-resolution 1 min means were available from on-site storage via modem in near-real time, longer-period averages and standard deviations could be computed for the model if desired.

e. Wind engineering

The wind-engineering community designs and tests structures affected by wind. It is responsible for development of structural design standards and codes that affect public safety and the economic health of the building industry. Annual losses from wind damage are high among the list of natural disasters affecting the United States.

Many wind engineers have relied on fastest-mile wind data for development of extreme wind climatology. The old triple-register wind recorders used for fastest-mile wind measurements are nearly phased out, so the engineers have had to develop methods of converting NWS wind reports to fastest-mile estimates. In addition to extreme wind-gust data, longer-period mean winds are of interest. According to Richard Marshall (1990, personal communication), neither the peak gust nor sustained (1 min) wind are adequate for predicting the maximum structural response of tall, slender structures and long-span bridges; longer-period means are required. In addition, WMO wind-sampling recommendations are appearing in European and International Standards Organization building standards. This has implications for the ability of the U.S. building industry to compete in international markets. Archival of high-resolution wind data in the manner described above would satisfy most concerns of the wind-engineering community. However, the fastest-mile wind would still be unavailable, and they would prefer a peak 2–3-s mean gust rather than the ASOS peak 5-s mean. Wind engineers are also interested in the 1- and 10-min mean winds occurring at the time of the peak gust. This information could also be computed from an archival of high-resolution wind data, as discussed in section 5c.

f. Air transportation

Nearly all ASOS stations will be at airports, where they will help to meet FAA requirements. FAA air-traffic control services are responsible for informing aircraft of pertinent weather and runway wind conditions during takeoff and landing. In addition, the FAA investigates accidents and needs access to archives of high-resolution surface wind data.

As discussed in section 3, the WMO recommends 2-min averages of wind speed and direction for air-traffic control purposes. It is conceivable that, by making appropriate changes to the wind-sampling algorithm, 2-min averages could be updated every 5 s for alerting aircraft on takeoff and landing at the airport, while 10-min and peak 1-min and 5-s hourly winds could be determined for dissemination across the weather networks. The consecutive 10-min mean and peak gust data mentioned in section 5a would be desirable for meteorologists forecasting during severe weather threats and should also be possible subject to longline data-transmission-load traffic. The high-resolution archive of 1-min data, as discussed in section 5c, would be available for accident investigation studies.

6. Concluding remarks: An alternative sampling and archival strategy

The optimum averaging time for surface wind observations depends upon the application, and, at least for non–real time usage, a high-resolution archive will allow calculation of nearly any average of interest. Adoption of the following recommendations in a revised ASOS wind-sampling strategy should reassure a broad cross section of users, while satisfying FAA, NWS, and DOD requirements for aviation services. These recommendations are summarized and contrasted with ASOS in Table 1.

1) High-resolution archive: A high-resolution archive using recent advances in mass storage and data-compression techniques is the key to an observing system that satisfies a majority of users from a broad base of interests. This archive should consist of the 1-min average wind speed and direction, with the peak 5-s average over the minute and the standard deviation of the 5-s mean speed and direction about the 1-min means. After spending so much to develop ASOS, we should not allow destruction of potentially important data; archival of high-resolution data at NCDC is crucial and will cost <1% of the original ASOS budget.

2) International measurement standard for hourly

TABLE 1. ASOS vs recommended wind-sampling and archiving strategies.

Wind requirement	ASOS	Recommendation
Air-traffic control (local use)	2-min average speed, direction updated every 5 s	Same as ASOS
Surface hourly observation (long-line transmission)	• 2-min avg. speed, direction • Remarks for wind squall, peak wind, wind alert, wind shift, variable wind remarks • Ob. time refers to end of 2-min period	• WMO 10-min avg. speed, direction • Peak 5-s, 1-min speeds during 10-min ob • Peak 1-min 5-s speed, direction, time during hour • Remarks as in ASOS, but in ref. to 10-min mean • Ob. time refers to midpoint of 10-min averaging period
Severe weather	• AWIPS alert mode: Surface obs. at 15-min intervals • AWIPS Warning Mode: Surface obs. at 5 min intervals • No emergency power • Max measurement 65 m s^{-1}	• No alert mode • Warning mode only: Surface obs. at 10-min intervals (10-min mean, peak 1-min, 5-s means for each 10-min period) • Emergency power • Max measurement 80 m s^{-1}
Archival	• Climatic wind products computed at ASOS site, transmitted long-line to NCDC • Daily avg. wind from twenty-four 2-min avg. hourlies • Peak 5-s avg. for day • All transmitted hourlies • 31-day storage locally, NCDC permanent storage	• 12 h of high-resolution wind data collected and sent twice per day to NCDC via network file transfer, all climatic wind products computed at NCDC • High-resolution data for each min: —1-min avg. speed, direction —Peak 5-s speed during min —Standard deviation of 5-s avg. speed and direction about 1-min avg. —All data archived permanently at NCDC

observations: For real-time use, international standards should drive the choice of averaging time. With relatively low-cost software modification to the ASOS wind-measurement algorithm, the hourly surface airways observation could be redefined to be consistent with WMO recommendations and provide extreme-wind information. This modification would include the 10-min mean wind and direction, and the peak 1-min and 5-s mean winds during the 10-min period and during the previous hour.

The NWS deserves credit for a great deal of progress toward the difficult goal of modernization and associated restructuring (MAR).

3) Observation time: All observation time ambiguity should be removed. For an hourly to be truly valid for the observation time, the wind measurement should be made between 5 min before and 5 min after the hour. Alternatively, the time of the surface observation could be designated as the actual midpoint of the wind-sampling period, with other, less variable surface parameters measured close to the midpoint time for better incorporation into assimilation schemes.

4) Special real-time warning data: Under specified criteria, such as the AWIPS warning or alert modes, 10-min means, with the peak 1-min and 5-s means, could be transmitted every 10 min.

5) Severe weather design: To enhance data collection during severe weather, backup power and survivability design should be built into the ASOS hardware, thus making wind measurements possible up to 80 m s^{-1}.

The NWS deserves credit for a great deal of progress toward the difficult goal of modernization and associated restructuring (MAR). According to the NWS Transition Program Office (1989), "periodic reexamination and possible adjustment of modernization goals or schedules" is a recognized part of the MAR. This paper strongly recommends that a careful reexamination of the wind-sampling and archival components of ASOS be conducted. Although the operational and research concerns addressed here represent a good cross section of potential ASOS users, they are by no means complete. The above recommendations can serve as a starting point for a forum on revision of the ASOS wind-measurement algorithm. The Office of the Federal Coordinator for Meteorological Services and Supporting Research is planning a workshop on this topic, which should be attended by many diverse users of wind observations.[1]

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[1]The workshop was held 29–30 October 1992, in Rockville, MD. A concensus was reached on the development of a surface wind standard—"Standard Method for Characterizing Surface Wind." A draft is currently under review and is available upon request from OFCM.

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