A COMPARISON OF CEILING AND VISIBILITY OBSERVATIONS FOR NWS MANNED OBSERVATION SITES AND ASOS SITES

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Abstract

The National Weather Service modernization program involves, among other things, a shift from manned weather observation to automated, unmanned instrument sensing. The Automated Surface Observing System (ASOS) is the device that will replace the conventional manned weather observation in use today. ASOS observations of ceiling and visibility were compared to the standard manual observations at 16 sites having at least four months of overlap data.

The 16 sites were located in the central plains states of Colorado, Nebraska, Missouri, Kansas, Oklahoma, and Texas. The period of study was confined to the precommissioning period of the sites when both conventional data and ASOS data were available. The study spans from mid September of 1991 to late July 1992, with the greatest amount of data collected between February and June 1992.

The overall results show that ASOS ceiling reports were within 1000 ft of conventional ceiling reports 92.7% of the time. Similarly, ASOS derived visibility was within one reportable category of conventionally derived visibility 93.7% of the time. These percentages were determined from a data base composed of approximately 64,000 observations.

During periods of active weather that would require a weather type entry into the coded observation, the high level of equality is decreased. The percentage of visibility reports

within one reportable category is 60.8% and the percentage of ceilings within 1000 ft of conventional reports is 76%. These percentages were determined from a data base of approximately 9,300 observations containing a current weather entry.

There were 5,263 cases of conventionally observed weather that would be categorized as requiring IFR (Instrument Flight Rules) by the FAA (Federal Aviation Administration) for safe air travel. ASOS observations correctly identified 4,499 of these events for an 85.5% equivalency rate. ASOS observations indicated 5,129 IFR occurrences, or nearly the same amount as conventional observations.

Fog is the most frequently reported weather phenomena when large discrepancies occur between conventional and ASOS ceiling or visibility reports. This investigation shows that ASOS reported visibilities in foggy conditions are generally higher than those reported by conventional means. Ceilings in foggy conditions as reported by ASOS are generally much lower than those reported conventionally.

ACKNOWLEDGMENTS

The data used in this study was available from the NWS, Office of Meteorology, Climate Data Continuity with ASOS Project under NOAA grant #NA90RAH00077. Part of the work was supported by the Colorado Agricultural Experiment Station.

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1.0 INTRODUCTION

An investigation of ceiling and visibility values reported by conventionally manned National Weather Service (NWS) sites and precommissioned Automated Surface Observing System (ASOS) sites has been conducted. These two weather elements comprise the day to day flight rules by which safe air travel is regulated. Very little has been published concerning the reporting characteristics of ASOS with respect to ceiling and visibility. This is partly due to competitive bidding restrictions and continually changing plans and schedules within the NWS modernization program (Miller 1992). At the time of this writing, no published investigation has been done to compare the ASOS visibility reporting with the conventional manned visibility reporting. The comparison of ceiling reports was necessary to gain an overall evaluation of these two critical parameters and the impact of the results of this investigation on the flying community. This investigation examines the data set, compares conventional visibility and ceiling values with those produced by ASOS, and discusses the findings.

1.1 MODERNIZATION

Modernization of the NWS, a major component of the National Oceanic and Atmospheric Administration (NOAA) of the Dept of Commerce, has been ongoing for nearly a decade. A portion of this modernization involves the automation of the surface weather observation.

There are two main reasons for modernizing the NWS. According to the National Research Council (NRC 1991) the first reason is the obsolescence of the communication and information processing thus making the current systems highly costly to maintain. The second reason is new scientific and technological breakthroughs that can provide an opportunity for the first time to analyze and predict destructive weather patterns that have, up to now, only been identified at the time of occurrence. (DOC 1990)

Visual examination by a human observer using instruments and personal interpretation of the human senses has been the standard form of recording weather phenomena for almost all of history. Procedures for developing trained observers to record objective and uniform phenomena world wide has existed for over 100 years. The most recent updates for training the human observer in reporting the state of the atmosphere, in particular cloud height and visibility, is outlined in Volume I of the Federal Meteorological Handbook (FMH-1) printed by the U.S. Govt. Printing Office for the Dept of Commerce (1982).

The program designed to automate surface weather observations is ASOS. It is a major system acquisition, managed by NOAA and sponsored by NOAA, the Federal Aviation Administration (FAA) and the Department of Defense. A total of 1700 ASOS systems is planned for complete modernization of the surface observing network.

Until completion of the NWS modernization, the surface observations reported by ASOS will not provide the same amount of data nor the same quality of information obtained by conventional human observers. Therefore success in the modernization program will continue to be undeterminable until all facets of its far reaching impact are complete. A program to demonstrate the proposed success of new technology has been developed and is currently operational. The Modernization and Associated Restructuring Demonstration (MARD) is a cost effective way to illustrate service improvements without the grand scale disruption of full modernization.

1.2 THE DATA SET

The data used for this investigation was collected by the National Climatic Data Center (NCDC) and supplied to Colorado State University for use in the study of climate data continuity. Hourly observations from 16 NWS First Order weather stations in six states were used to compile the data base. The 16 stations compose the basis for the surface observation network in the MARD. This area was chosen for it's high probability of severe weather and because the advanced facilities at Denver/Boulder, Kansas City, and Norman/Oklahoma represent the state of the art technology that Modernization is aiming for in communications and data processing (Doc 1990). Cloud information, visibility and weather information were used in this study, however, the final data set included other meteorological variables as well.

The Collocation of each site, ASOS and manned NWS observation point, is generally a few hundred yards, but at some sites is more than a mile away. The implications of this distance difference will be discussed in section 7.2.2.

1.3 PURPOSE

The magnitude of the National Weather Services modernization program causes its implementation to span many years, before completion. In the interim, it's imperative to maintain the high standards of the existing service and to continue this service without interruption to the many and varied customers who have come to rely upon it. These very concerns are reflected in Title IV, of Public Law 100-685 (U.S. Congress 1988) which states that implementation of NWS modernization programs will not result in a degradation of services. As such, these programs stretch technology to equal the value and precision of human observations, but with the consistency and persistence of computer technology.

During this transition period, the aviation community will look closely at the changes in the reporting of their most important weather phenomena, ceiling and visibility. More frequent reports of weather conditions that meet Instrument Flight Rules (IFR categories) can result in huge fuel expenses, IFR weather requires greater fuel reserves to be carried and a heavier takeoff weight. The impact of automated weather reporting in mishap investigations by the National Transportation Safety Board (NTSB) has yet to be experienced in practice. Already the NCDC has voiced concern about the continuity of the national climatic data base.

The use of MARD data also puts an urgency to evaluate the instruments in the field, before the availability of collocated observations is lost. Once an ASOS site is commissioned, the ASOS observation becomes the official observation and archiving any conventional observation after commissioning is not required.

2.0 THE AUTOMATED SURFACE OBSERVATION SYSTEM

The ASOS instrument package consists of eight sensors from various vendors with room for more when technology becomes available. The "ASOS Combined Sensor Group" is the term applied to the following array (Users Guide 91):

Wind	Precipitation identification
Pressure	Freezing rain identification
Liquid precipitation accumulation	Ambient and dewpoint temp
Cloud height below 12,000 ft	Visibility

Future sensors may include the following phenomena not presently reported by the current configuration of ASOS (Users Guide 91).

Thunderstorms	Snow depth
Hail	Water equivalent of snow
Blowing obstructions	Clouds above 12,000 ft
Smoke	

The ASOS Combined Sensor Group (ASOS/CSG) is located just off the primary designated instrument runway. The pressure sensors are located indoors at the Acquisition Control Unit (ACU). At some airports a center field ASOS/CSG will also be in place. Where needed, a second type of sensor array, called a Touchdown Sensor Group (ASOS/TSG), which is a visibility and cloud height indicator, will be placed at the touchdown zone on the principle instrument runway. All sites within the MARD were designed in accordance with the Federal Standards for Siting Meteorological Sensor at Airports (FCM-S4-1987).

Figure 2.0.1 shows the general appearance of the ASOS-CSG. The Data Collection Package or DCP transmits the observation elements to the ACU for display, dissemination, and electronic voice broadcast for ground to air radio broadcasting through the FAA, and dial in general public access.

Figure 2.0.2 shows a typical ASOS/TSG. It also has a DCP which transmits data to the ACU, but only visibility and cloud height are collected. This investigation deals mainly with the Cloud Height Indicator (CHI) and the visibility meter. However algorithm interdependency plays a role in the outcome of the reported values. For instance, at the ACU, if the reported visibility is 3 miles and the temperature and dewpoint instruments indicate a dew point depression of four degrees or less, then an obstruction to visibility is added, in this case fog. If the temperature/dewpoint depression is more than four, haze would be reported (DOC 91).

A key instrument in duplicating the Standard Aviation Observation, or SAO, is the precipitation identification sensor, otherwise known as the Light Emitting Diode Weather Indicator (LEDWI). It determines weather elements of precipitation as heavy rain (R+), light rain (R-), rain (R), heavy snow (S+), light snow (S-), snow (S), and light precipitation (P-). But unlike the human observer, the intensity (+ or -) is not based on low visibility but from an algorithm based upon sensor response. Therefore, an SAO from ASOS that indicated 5S+ would be highly unlikely from a human or conventional observer, since S+ would be determined based upon a much lower visibility, e.g. ½ S+.

The difficulty in automating these subjective elements brings fundamental changes to the observation technique used to determine ceiling, visibility and weather type. Because of

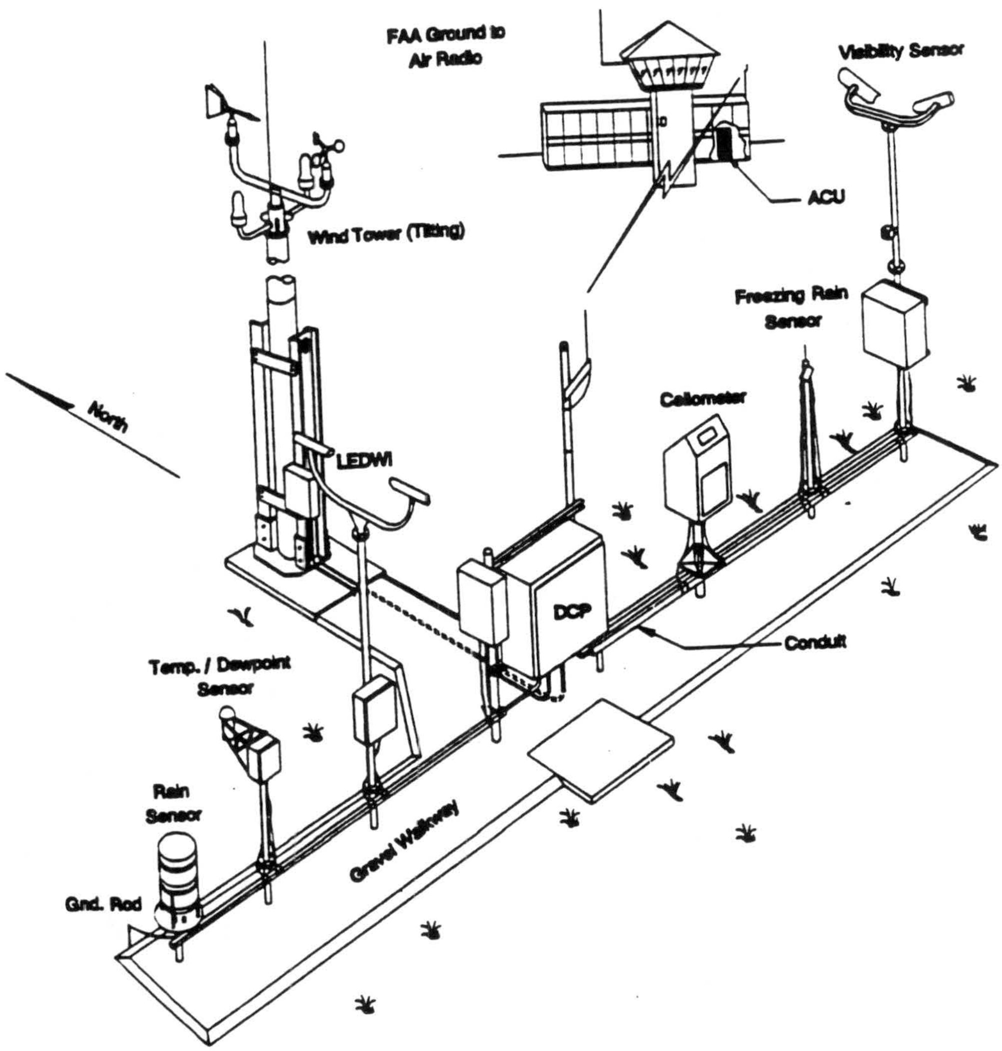


Figure 2.0.1. The Automated Surface Observing Site (ASOS) Combined Sensor Group (CSG).

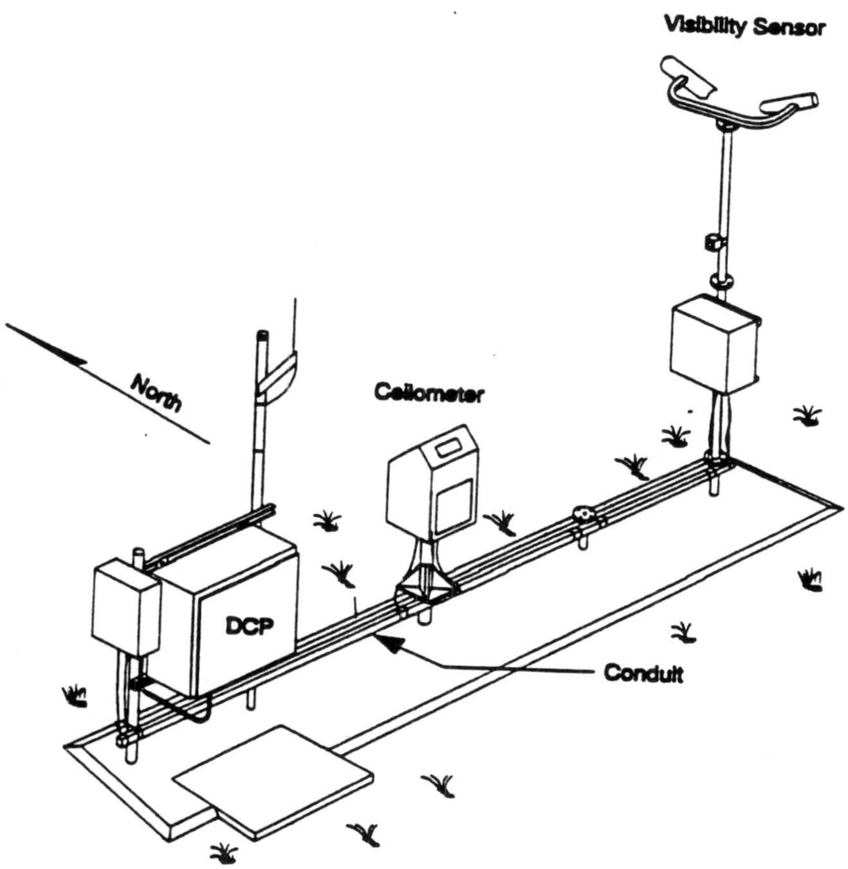


Figure 2.0.2. The ASOS Touchdown Sensor Group (TSG).

possible risks and also to comply with Public Law 100-685 (which states that modernization cannot reduce or deny services that currently exist) augmentation by humans is allowed to clarify SAO reports produced by ASOS. The identifying mark of an ASOS SAO is the three character group "AO2" immediately following the time of occurrence. To augment the observation and clarify the subjective elements or add to the observation a phenomena not reported by ASOS (i.e. tornadoes, or thunderstorms) the AO2 group becomes AO2A indicating some manual editing was done.

Other differences between human (hereafter called conventional or simply CONV) observations and ASOS observations are a result of limits to technology. ASOS reports clouds below 12,000 feet, higher clouds are not reported. ASOS visibility is reported in 16 categories, the last of which groups all visibilities of ten miles or greater as "10+" which conventionally may be 12 miles or 120 miles. ASOS, as mentioned, cannot detect tornadic activity, thunderstorms, snow depth or rate of accumulation, distant phenomena or blowing phenomena, so augmentation, even though it undermines the goal of automation must be used.

2.1 THE CLOUD HEIGHT INDICATOR

The Cloud Height Indicator (CHI) used on ASOS is a Vaisala laser ceilometer. The near infrared (0.9 micron) source is provided by a gallium arsenide array that is pulsed at about one kilohertz. It differs from the standard Weather Service Vaisala ceilometer (1985 NWS contract) in the way it processes returns for low cloud base and total obscuration (Nadolski 91).

Since laser ceilometers have been in use since the mid 1970's their strengths and weaknesses are well documented. The automation of the cloud base and coverage parameter was fairly straight forward. Removal of subjective interpretation was necessary for obscured ceilings and cloud amount. Cloud coverage is determined by time averaging over a 30 minute period. Double weighting is placed on values produced in the past 10 minutes. Data is collected once every 30 seconds. Data that is reflective of a "hit" (cloud base has been detected) are rounded to the nearest reportable increment or "bin", then binned to the nearest 100 feet for returns up to 5000 feet. The "bins" double in size to 200 feet increments for hits between 5000 and 10,000 feet and then increase to 500 feet increments for hits 10,000 to 12,000 feet.

The sampling process of the CHI is a follows (from Nadolski 91): For every pulse, 254 samples are taken at 100 nanosecond intervals. The pulse is near one kilohertz, but the Users Guide states this frequency varies with temperature. A return that indicates a clean measurable cloud base is termed a status 1 (or S1) hit. Hits are then binned and another pulse is sent. This measuring cycle goes on for 12 seconds while bins are filled. A new measuring cycle begins every 30 seconds.

The sky condition algorithm collects data over a 30 minute period (60 measuring cycles) and performs simple accounting of the number of hits in each bin. For each minute, if five or more bin heights have been recorded, an algorithm is used to eliminate or group bins until only five bins contain recorded hits. These are then ordered lowest to highest and clustered, such that close lying increments will report as one layer, not as two cloud layers one or two hundred feet apart. The algorithm then selects up to three layers to become part of the SAO cloud group (Burch 93).

In precipitation events the vertical visibility (VV) algorithm developed by Vaisala is used for most occurrences. This algorithm incorporates signal attenuation on both outgoing and incoming path lengths, due to obstructing phenomena. A "VV" hit indicates that no cloud base has been detected but the return power is some fraction, say 50% of transmitted power. This would be a class "S3" hit. The geometric evaluation of a S3 hit would be the height at which the ground would no longer be visible. VV hits are binned just as "S1" hits are binned. If cloud hits and VV's are present, then the VV's are used if deemed appropriate by the algorithm. If there are VV's and no cloud hits, the median of the VV's is computed and reported as the cloud base (Nadolski 91).

In all cloud reporting, the last 10 minutes of data is weighed double, to respond to fast changing conditions. The cloud amount is produced from a time average algorithm. As with all laser ceilometers, they only detect what is directly overhead. They are placed as far from polarized light sources as possible yet as close to the active instrument runway as practical.

2.2 THE VISIBILITY METER

The visibility meter used on ASOS is a visible light, forward scattering Belfort model 6220. The scatter angle formed by the cone of transmission intersected by the cone of reception is from 20-50 degrees over a sampling volume of 2100cm^3. A xenon light source is pulsed for ½ microseconds at ½ hertz, or twice every second (Crosby 1993). It is accompanied by a day/night indicator that is used to switch algorithms from daytime to night time. The sensor samples data every 30 seconds, computes an extinction coefficient, computes a one minute arithmetic mean using the average between the current sample and the last sample, then stores this value in a ten bin "stack". Once each minute, the harmonic mean, Eq. 1, is computed for the 10 values in the stack. If fewer than 8 are present a missing visibility is reported. The value of the harmonic mean is then rounded to the nearest reportable increment. If substantial difference is noted minute by minute, then a variable visibility is reported.

$$\frac{1}{H} = \frac{1}{n}\left(\frac{1}{X_1} + \frac{1}{X_2} + \ldots + \frac{1}{X_n}\right) \tag{1}$$

where H is the harmonic mean and X is the computed one minute visibility value.

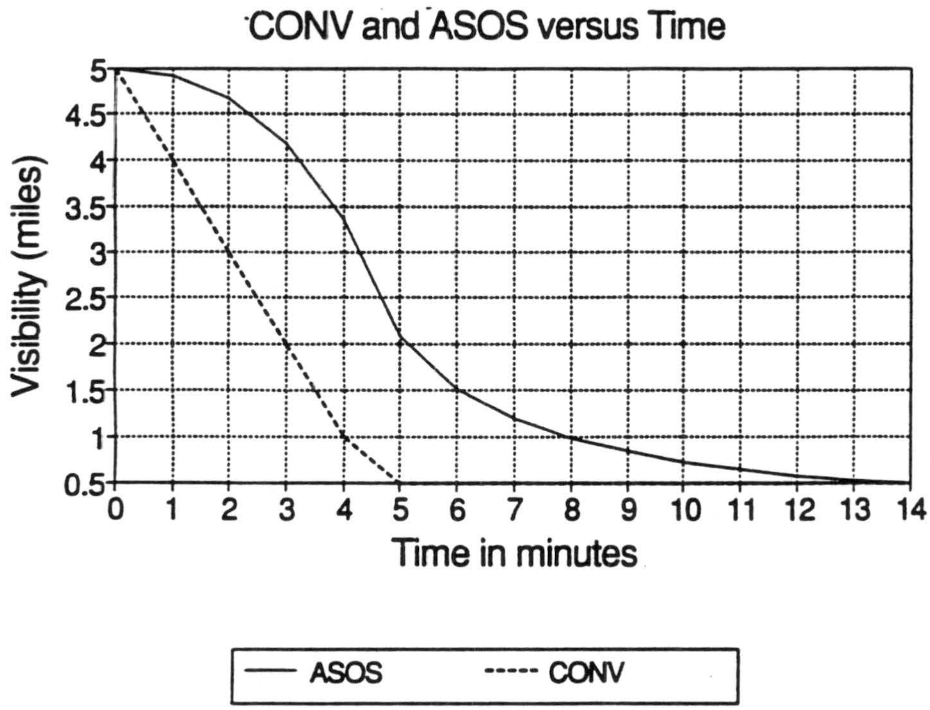


Figure 2.2.1. Instantaneous visibility as compared to a time averaged harmonic mean visibility produced by the ASOS visibility algorithm.

Figure 2.2.1 shows the comparison of a rapidly falling visibility with what value of visibility a ten minute harmonic mean would produce. The dashed line is an assumed variation of visibility with time. The solid curve is the result of the application of the ASOS algorithm indicated in equation 1.

The ASOS reportable increments for visibility are as follows:

<¼ mile, ¼ mile, ½, ¾, 1, 1 ¼, 1 ½, 1 ¾, 2, 2 ½, 3, 3 ½, 4, 5, 7, and 10+.

Visibilities between 5 and less than 7 are reported as 5, and visibilities between 7 and less than 10 miles are reported as 7 miles. Visibilities of 10 miles or greater are reported as 10+ (DOC 91).

Figure 2.2.2 shows a basic sketch of the visibility meter. It is mounted at a height of 10 feet and oriented northward. Heated hoods covering the optics prevent ice buildup and dew formation and their angle inhibits birds from building nests. Spikes on the hoods prevent the tail feathers of perching birds from obstructing the light beams. Since the sample area is small, more than one visibility meter is advisable in areas where differential visibility is common.

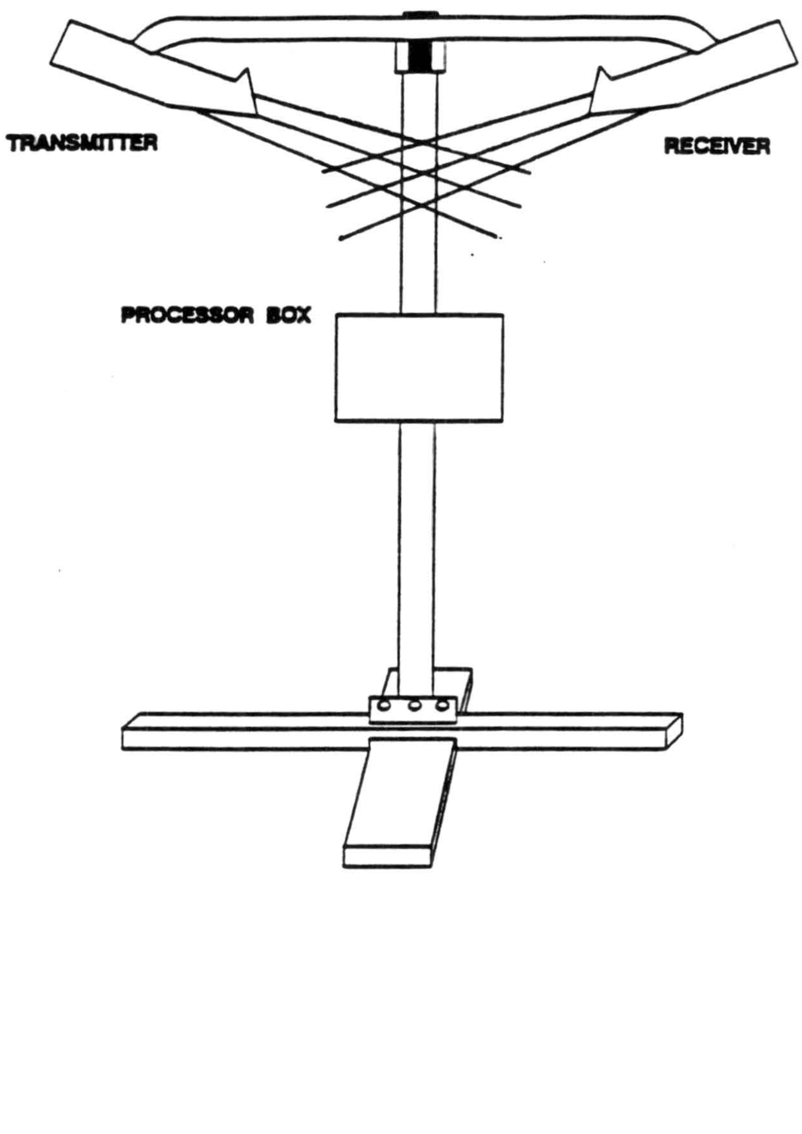


Figure 2.2.2. Schematic of the ASOS visibility meter.

3.0 THE DATA SET

As mentioned in Section 1.2, the data set of hourly observations came from the MARD area. Selection of the sites was made by NWS personnel in developing the program. Figure 3.0.1 shows a map of the MARD region. After a precomissioning period many of the ASOS sites became the official weather observations and the flow of hourly conventional data ended. Data collected for this study was from the precomissioning period (14 Sep 91 - 30 Jul 92) and represents a unique data source of concurrent CONV and ASOS values.

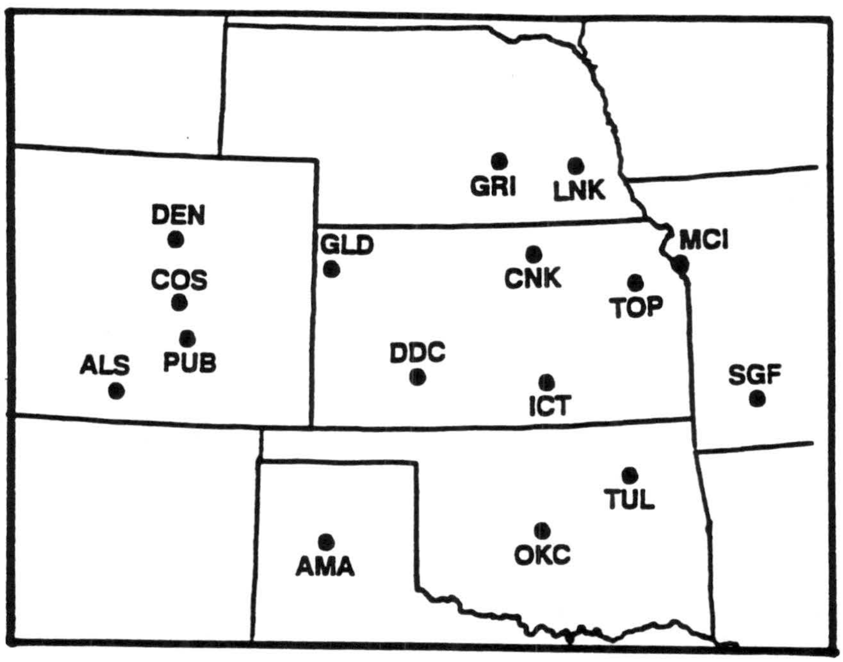


Figure 3.0.1. Locations of the sites used in this investigation.

The data was occasionally irregular with periods of missing one or both ASOS and CONV observations. No observation was discarded if only one of the two investigated elements was missing. Since the instruments were not commissioned, the weekend or holiday repair and maintenance may have lapsed to the next work day. Such conditions as repair or replacement were not considered in the data, and lapse of maintenance on broken instruments would be noted as missing data in the ASOS SAO.

All sites were put into a single population for the primary data source. Analysis of individual site data for ceiling and visibility indicated no significant differences among sites. Some sites were operated at less than full time (24 hour operation). Only the times when ASOS and CONV data were both available did the data go into the general population. Table 3.0.1 shows the percentage of usable data from each site.

3.1 SEASONALITY

Data collection took place for a period of about 10 months beginning in September of 1991 to August 1992. Many of the sites were accepted later in the period. Figure 3.1.1 shows the beginning and ending period for each sight. Most of the data represents late winter and most of spring for each site. This seasonality was important in the MARD program to try and experience violent spring weather in the central plains. There is some indication in the data that during extreme weather, ASOS information was not available.

Because of this seasonality, paired information has not been collected to reflect a full annual cycle, extreme heat, or cold events. About 9000 matched observations out of 64,000 contain reportable weather.

3.2 SITE LOCATIONS

All ASOS locations were site surveyed in accordance with strict NWS standards for locating weather instruments. However the existing manned NWS observations may be relatively close or more than a mile away from the "end of runway" ASOS site. The distances between the observation sites to be compared will cause some differences, especially in the

Table 3.0.1. Data Distribution by Site.

Name	Identifier	% of all Ceilings	% of all Visibility
Alamosa, CO	ALS	3.23	3.17
Amarillo, TX	AMA	3.75	3.86
Concordia, KS	CNK	4.25	4.32
Colorado Spgs, CO	COS	9.32	9.14
Dodge City, KS	DDC	5.58	5.76
Denver, CO	DEN	8.42	8.35
Goodland, KS	GLD	4.00	3.59
Grand Island, NE	GRI	8.57	8.72
Wichita, KS	ICT	5.28	5.38
Lincoln, NE	LNK	10.65	10.83
Kansas City, KS	MCI	5.51	10.24
Oklahoma City, OK	OKC	3.19	3.28
Pueblo, CO	PUB	5.89	5.78
Spingfield, MO	SGF	5.73	7.71
Topeka, KS	TOP	11.12	11.33
Tulsa, OK	TUL	5.51	5.32

point valve sensors, mainly visibility weather type and ceiling. Implications of this will be discussed in Section 7.2.2

3.3 PERIODIC EPISODES DUE TO MISSING PAIRS

At some sites, periods of no matching observations exist. For instance, Alamosa (ALS) is not a full time observing site, so matched pairs of observations occur only during hours of operation. The effect of this on the final data base is almost lost by conglomeration

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	1991				1992							
ALS		16								18		
AMA							4			18		
CNK						5				18		
COS		16									28	
DDC					8					19		
DEN			13								27	
GLD					30					20		
GRI		16								20		
ICT						7				20		
LNK	16										30	
MCI						12					30	
OKC						26				18		
PUB			13								28	
SGF						17					30	
TOP	14										28	
TUL					15					18		

Figure 3.1.1. Data distribution by time for each site.

of all sites into one data set. At other sites, repair work of disabled instruments was not performed until the next workday. If over a weekend, this would mean Monday. This effect on the data base is eliminated by eliminating non-matched pairs. Other reasons for missing data include the occurrences of failure during severe weather, and scheduled maintenance of non-sensor components that require shutting down the entire array.

3.4 DEFINITIONS AND DELETIONS

Some data obtained by NCDC from the MARD contained non-unique duplicates, such as conventionally "cored" or corrected observations. These cored observations took priority over the originally transmitted observation which was deleted. Other causes for deleting an observation include: ambiguous or otherwise uncorrectable format errors in ASOS data; erroneously encoded conventional observations that could not be manually corrected; and off hour specials, of which only a few were encountered. A matched pair of observations consist of one ASOS and one conventional (CONV) SAO taken as an hourly or record special or a manually corrected CONV and the appropriate ASOS observation for that hour.

3.4.1 Ceilings

A ceiling is defined as a layer of clouds that exceeds a specified areal coverage and is referred to in terms of the cloud height. The ceiling defined for the purpose of this investigation is the first broken layer or greater of cloud amount that is reported in the SAO. The ASOS Ceilometer algorithm reports cloud groups as "scattered" (10-50% coverage) "broken" (60%-90% coverage) and "overcast" (100% coverage) using a time averaging schedule over a ten minute period (DOC 1992). The same is generally true of CONV observations except it is the observers trained eye that estimates spacial averages over the entire sky. Obscuration reports such as W6X (vertical visibility is 600 feet with obscured ceiling) are recorded as 600 feet. For conventional observations of "E" or estimated height, the value was used as reported. Variable values of ceiling in ASOS and conventional observations were used as the lowest reported value, if two were reported, but also 'flagged' in the final data set as being variable. Any information on ceilings that appear after the wind group in the SAO, usually reserved for remarks, was deleted. Conventional ceilings above 12,000 feet, the limit of ASOS's capability, were classified as "clear sky" or "No Cig" so as to agree with the automated output of "CLR BLO 120" from ASOS.

3.4.2 Remarks and "Variable" conditions

Data in the Remarks section of the SAO was ignored. Not because it wasn't considered useful or accurate, but because of difficulty in just how to determine a unique value. Much of the ceiling and visibility information found in the remarks section consist of ranges. For instance, if the cloud group of an SAO has a ceiling reported as 500 feet variable and the remarks read ceiling 200 to 700 feet, there is too much subjectivity to enter anything but 500 feet into the data population. Even though the data was not used, a flag was set for each occurrence of a variable comment ("V") attached to a ceiling or visibility value when in the cloud and/or obstructions to visibility and current weather group. For instance, a value of 2 1/2 VS+ in an ASOS observation would be set as 2 1/2 miles visibility but variable. Where as an observation such as 3/4 F with a remark of "tower visibility 3 miles" would be set in the data base as 3/4 mile visibility. Therefore only data encoded in the original SAO group as being variable gets flagged as variable. Comments regarding variable conditions that appear in the remarks section are excluded from the data set. During the analysis, the flag indicator was used to stratify data.

3.5 DEFINITION OF SUBSETS FOR ANALYSIS

The data provided by NCDC was sequenced by day and by hour. All dates were sorted by city, and all the hourlies for each city were paired up with matching ASOS and CONV observations. This gave an intermediate (complete SAO) data base consisting of 16 files, one for each city, sequentially listing matched pairs of ASOS and CONV observations. This data base was then duplicated and the duplicate was stripped of unnecessary information to yield the final data set. The final data set is one file which lists all 16 cities alphabetically.

Julian date and hour of observation are sequentially listed within each city. The flags for variable ASOS or CONV values plus the weather reported by ASOS and CONV sources are also listed.

Table 3.5.1 Example of Final Data Set

Key

STA	DATE	TIME	ASOSCIG	V	CONVCIG	V	ASOSVIS	V	ASOSWX	CONVVIS	V	CONVWX
ALS	92103	0700	12000		25000		10+			120		
ICT	92103	1000	3500	V	5000		3.5		R+F	2.5		TRW+
LNK	92105	1700	00100	V	00500	V	0.75	V	S-F	0.5	V	S+BS
MCI	92105	2200	10000		25000		5.0		P-	3.5		L-F

Example from the data file

```
ALS,91345,1800,01700, ,04000, , 11.00, ,     , 10.00, ,
ALS,91345,1900,01900, ,02000, , 11.00, ,     ,  2.00, ,
ALS,91345,2000,00800, ,02000, ,  0.75, ,SF   ,  0.50, ,SW-F
ALS,91345,2100,00300, ,00500, ,  0.25, ,S+F  ,  0.25, ,SW-F
ALS,91345,2200,00300, ,00400, ,  0.25, ,S+F  ,  0.06, ,S+F
ALS,91345,2300,00400, ,00400, ,  0.50, ,SF   ,  0.25, ,S+F
ALS,91346,0000,00400, ,00400, ,  0.75, ,SF   ,  0.50, ,SF
ALS,91346,0100,01300, ,00600, ,  2.50, ,SF   ,  1.50, ,S-F
ALS,91346,0200,01200, ,00600, ,  1.50, ,S-F  ,  1.00, ,S-F
ALS,91346,1500,00100, ,02000, ,  0.25, ,F    ,  0.12,V,F
ALS,91346,1600,00100, ,00000, ,  0.20, ,F    ,  0.25, ,F
```

Legend

STA ...... Station Identifier
DATE ..... Last two digits of the year and the Julian day of that year
TIME ..... Time GMT in using 24hr clock
ASOSCIG .. Five digit ASOS reported ceiling
V .... "V" if previous entry was reported as being variable (same throughout)
CONVCIG . Five digit CONV reported ceiling
ASOSVIS .. Visibility as reported by ASOS
ASOSWX .. Current weather as reported by ASOS
CONVVIS . Visibility as reported by CONV means
CONVWX . Current weather as reported by CONV means

Table 3.5.1 illustrates the format of the final data set used in this investigation. The intermediate data set, with all other information, remarks, temperature, etc. was maintained to investigate elements not carried into the final data set.

3.5.1 Current Weather Flags

The format of the final data set lends itself to easy and quick manipulation. One such method used was to compare visibility values when it is raining or snowing or whenever some type of conventionally observed weather was being reported. By scanning through the data file and compiling a subset of all lines where weather of interest is occurring, you can avoid doing lengthy statistics on unwanted data. This method of making subsets by exclusion is fast and dependable. The current weather oriented manipulations involved using any comparison that contained the wanted symbol representing the weather of interest. For example, to look at comparisons of ceiling and visibility during periods of fog, any observation with an "F" encoded would be used, whether it was something like ½F of 3S+FL-.

3.5.2 Ceiling and Visibility Flags

The same principle described above was used for numeric values also. Using the hour of observation, one could investigate only night observations or observations during hours of twilight. Most commonly it was ceiling and visibility data that was used to define some subset to evaluate. Since these values are numeric, ranges could be used to filter out unwanted data. For instance occurrences of ceilings below 3000 feet were evaluated just as were occurrences of ceilings between 5,000 and 10,000 feet. By flagging these values and then comparing the two instruments, insight into the behavior of the visibility meter during low ceiling events could be examined as well as behavior of the CHI in poor visibility situations.

3.5.3 Instrument Flight Rules

Instrument Flight Rules are an exhaustive set of regulations that must be followed when flying in certain weather conditions. A full description of what must be done to safely fly in IFR conditions is described in PART 91 "General Operating and Flight Rules", Dept. of Transportation 1992. For this investigation, the combination of two conditions generally agreed upon in the aviation community to require activating IFR flight restrictions was used. These conditions are a ceiling of 200 feet or more, but less than 1000 feet and/or visibility of 1/2 mile or more but less than 3 miles. By combining the flags on ceiling and visibility ranges to the final data set, one was able to subset all occurrences of IFR weather where both ASOS and a conventional observation were available for comparison. Total IFR comparisons amounted to about 5,200 pairs or around 8% of the total data.

4.0 COMPARISON OF CEILINGS

In performing the comparison of ASOS reported ceilings with conventionally reported ceilings, one must bear in mind that laser ceilometers were used for both evaluations; those by human observers and of course the ASOS instrument. The real comparison involves the subjective evaluation of the sky at an instant by the human observer and the subjective evaluation of the trace on the ceilometer the observer uses to make the cloud height report. The ASOS ceilometer uses time averaged algorithms and sampling intervals of ten minutes to determine amount of cloud.

4.1 METHODOLOGY

The method used for comparing values from the two sources is the scatter diagram from which a frequency distribution diagram is constructed. Each evaluation, whether done for a specific weather type or cloud height etc. produces scatter diagrams for both ceiling and visibility elements. Since similar values appear frequently, the number of occurrences were used to account for the positioning in the scatter diagram. In order to simplify the hundreds of possible outcomes of which a ceiling can be reported, categories were used to group the ceiling heights. The categories used are listed in Table 4.1.1. Since ASOS categories vary from conventional categories, some accommodation must be made to match equivalency with capability. For instance, ASOS can not report clouds above 12,000 feet so a CONV report of 25,000 OVC must be put into the same category as the CLR BLO 120 report generated by ASOS. In this way, clear skies and skies with no ceiling below 12,000 feet are put into the same category.

Table 4.1.1. Ceiling Categories

Conventional Range	ASOS Range[1]	Category in This Study[2]
0000 - 0900	0000 - 0900	≤ 1000
1000 - 1900	1000 - 1900	≤ 2000
2000 - 2900	2000 - 2900	≤ 3000
3000 - 3900	3000 - 3900	≤ 4000
4000 - 4900	4000 - 4900	≤ 5000
5000 - 5500	5000 - 5800	≤ 6000
6000 - 6500	6000 - 6800	≤ 7000
7000 - 7500	7000 - 7800	≤ 8000
8000 - 8500	8000 - 8800	≤ 9000
9000 - 9500	9000 - 9800	≤ 10,000
10,000+ & CLR	10,000 - CLR BLO 120	≥ 11,000

1. ASOS USERS GUIDE (Aug 1991)
2. All values are in feet. Scatter diagrams indicate category by flight level i.e. 1,200ft is flight level 012 and flight level 25,000ft is 250, etc.

Once a scatter diagram has been produced a frequency distribution diagram is made by summing the cells in the diagonals of the scatter diagram.

Figure 4.1.1 is an example of a simplified scatter diagram. Across the top is the category reported by conventional means. Down the side (in increasing order by category but not illustrated as "1-10" in the figure) is the category reported by ASOS for the same event. For events in which ASOS and conventional reports fall in the same category, a "hit" is scored and an incremental adjustment is added to the corresponding cell The diagonal row of cells from the upper left hand corner to the lower right hand corner constitute "hits". The sum of these cells in the diagonal row constitute the number of times ASOS agreed with the conventional report within the range of the category. The sum of all the diagonals produces

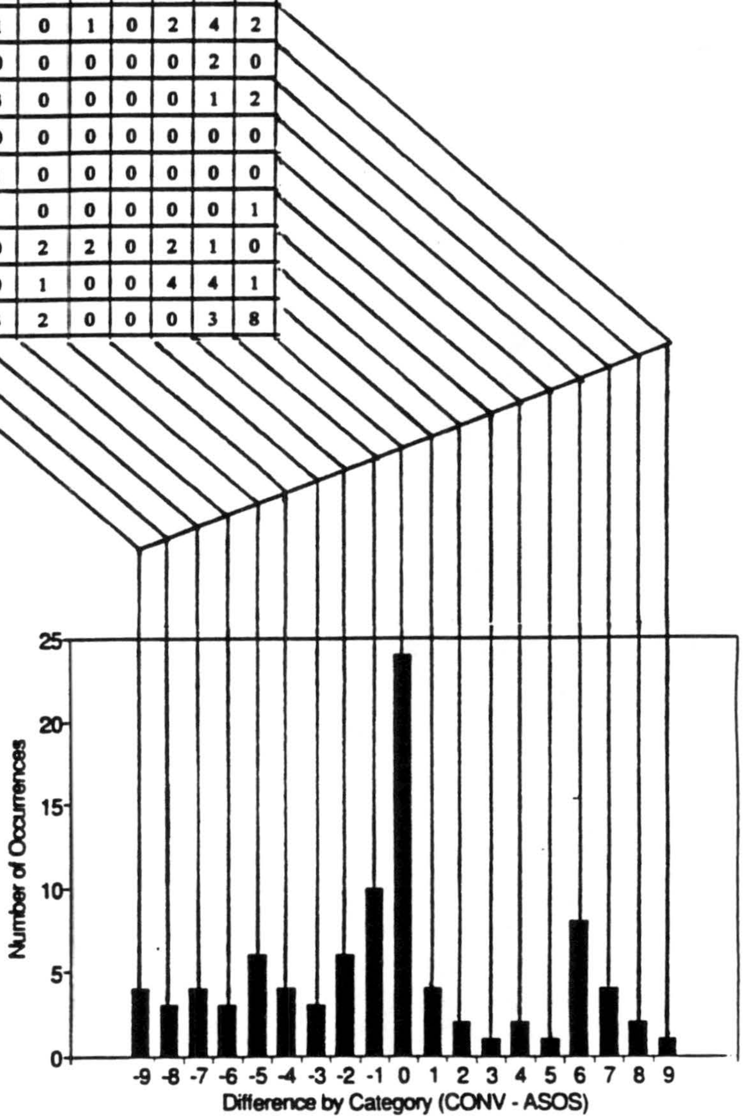
SCATTER DIAGRAM

Conventional Observations

CATEGORY

ASOS Observations

1	2	3	4	5	6	7	8	9	10
1	1	1	0	1	0	2	0	0	1
3	4	1	1	0	1	0	2	4	2
2	0	2	0	0	0	0	0	2	0
0	0	0	3	0	0	0	0	1	2
1	0	1	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0
0	0	1	.	0	0	0	0	0	1
1	0	4	0	2	2	0	2	1	0
1	1	0	0	1	0	0	4	4	1
4	2	2	3	2	0	0	0	3	8



Frequency Distribution Diagram
Example (92 Data Points)

Figure 4.1.1. Example of a scatter diagram and frequency distribution diagram.

a frequency diagram illustrating the number of occurrences of categorical equivalence. Regions of the scatter diagram depict different phenomena. The lower left hand corner represents the frequency of events in which the conventional report indicates a much lower category than the ASOS reported. The upper right hand corner represents the frequency of events where the conventional report is in a much higher category than the corresponding ASOS reports. Every diagonal group of cells represent one or more categories high or low from equivalency. On the frequency distribution diagram, the left hand side indicates the number of categories in which ASOS reported higher values than values from the CONV reports. The right hand side represents the number of categories in which ASOS reported lower values from CONV reports. All comparisons in this investigation are with respect to the conventional observation, i.e. ASOS reports higher or lower than CONV. Categories used to evaluate ceilings were as follows: less than or equal to 1,000 feet; 2,000 feet; 3,000 feet; 4,000 feet; 5,000 feet; 6,000 feet; 7,000 feet; 8,000 feet; 9,000 feet; 10,000 feet; and ≥10,000 feet. Therefore, three categories low could translate to a 3,000 foot discrepancy.

4.2 OVERALL COMPARISON

Using the total number of matched pairs for comparison (64,137 data points) 86.2% were "hits" and 92.7% were within plus or minus 1,000 feet. Fig. 4.2.1 shows the complete scatter diagram and associated frequency diagram. This result could be easily expected if you closely examine the number of occurrences in the lower right hand cell of the scatter diagram. This number (42,962) represents all occurrences of clear skies, or at least no ceilings below 12,000 feet. The dominating result of such a high number illustrates the fact that 67.0% of the cloud heights reported during the MARD were at or above the capabilities of the

Ceiling Scatter Diagram

Ceiling	Scatter	Cat.	(Flight	level)							Total
≤010	≤020	≤030	≤040	≤050	≤060	≤070	≤080	≤090	≤100	≥110	
3983	279	28	16	11	8	2	1	2	4	342	4676
391	2345	188	37	23	10	9	6	3	9	74	3095
86	346	1452	157	52	18	22	8	11	19	139	2310
47	63	284	1063	102	32	18	16	9	11	136	1781
44	44	73	316	995	142	45	32	11	19	164	1885
31	29	26	66	195	687	115	46	26	21	168	1330
7	6	23	28	61	133	492	104	42	24	135	1055
3	8	8	20	48	62	121	427	76	31	147	951
4	5	9	13	16	35	46	146	393	82	191	940
4	5	9	10	24	20	23	48	142	538	348	1171
41	79	121	199	178	217	145	284	239	558	42,962	44,943
4641	3209	2221	1925	1785	1284	1038	1038	954	1316	44,806	64,137

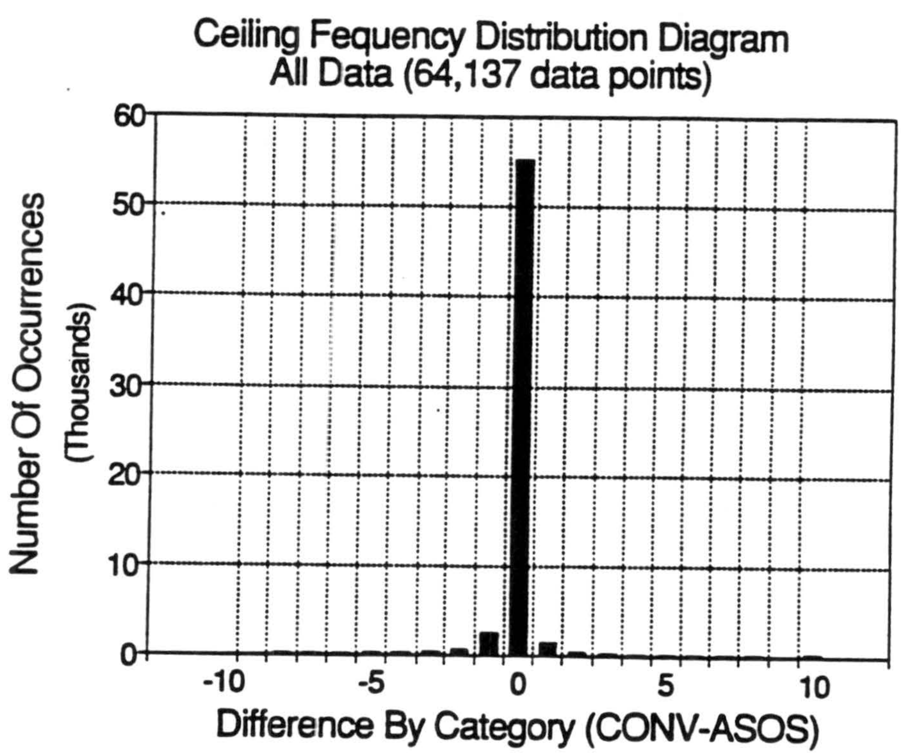


Figure 4.2.1. Scatter and frequency distribution diagram for all ceiling reports.

ceilometer. The high number of non-significant events produces a high equivalency rate when all 64,137 pairs of observations are compared.

4.3 COMPARISON BY WEATHER PHENOMENA

There were 9,454 events of reportable weather, of which 76.3% were reported by ASOS to be within ±1000 ft of agreement with CONV reports. Using the method of generating a subset by elimination, a population was produced that contained conventionally reported rain, snow, fog, or drizzle. This population contained 8,828 matched pairs or 93.4% of the total active weather data. Some observations were reporting only rain and some rain and fog, but the common occurrence in the population was the CONV weather contained one or more of the following entries; R, S, F, L. Figure 4.3.1 shows the complete scatter diagram for this evaluated population. The single most notable difference is the spread shown in the frequency distribution diagram, and the small population in the "Ten categories low" entry on the far right hand side. Further investigation shows that this population of 303 events represents, for the most part, weather phenomena in which the conventional reports indicated fog with no ceiling, and ASOS reported Fog with some associated low ceiling below 1,000 feet.

Ceiling Scatter Diagram

Ceiling	Scatter	Cat.	(Flight	level)							Total
≤010	≤020	≤030	≤040	≤050	≤060	≤070	≤080	≤090	≤100	≥110	
3258	154	18	11	6	6	1	1	0	1	303	3759
292	792	64	17	10	5	5	3	1	1	10	1200
73	140	307	43	22	12	14	7	4	6	14	642
38	34	88	269	44	18	6	5	6	7	11	526
39	24	25	102	263	48	14	13	3	6	10	547
23	18	12	19	75	137	33	14	7	6	5	349
4	3	8	8	14	38	83	21	12	5	10	206
3	5	2	7	21	11	24	54	14	7	7	155
3	2	4	4	5	13	13	24	47	14	9	138
3	2	1	6	8	3	5	17	22	55	20	142
26	16	11	19	24	25	14	36	32	48	913	1164
3762	1190	540	505	492	316	212	195	148	156	1312	8828

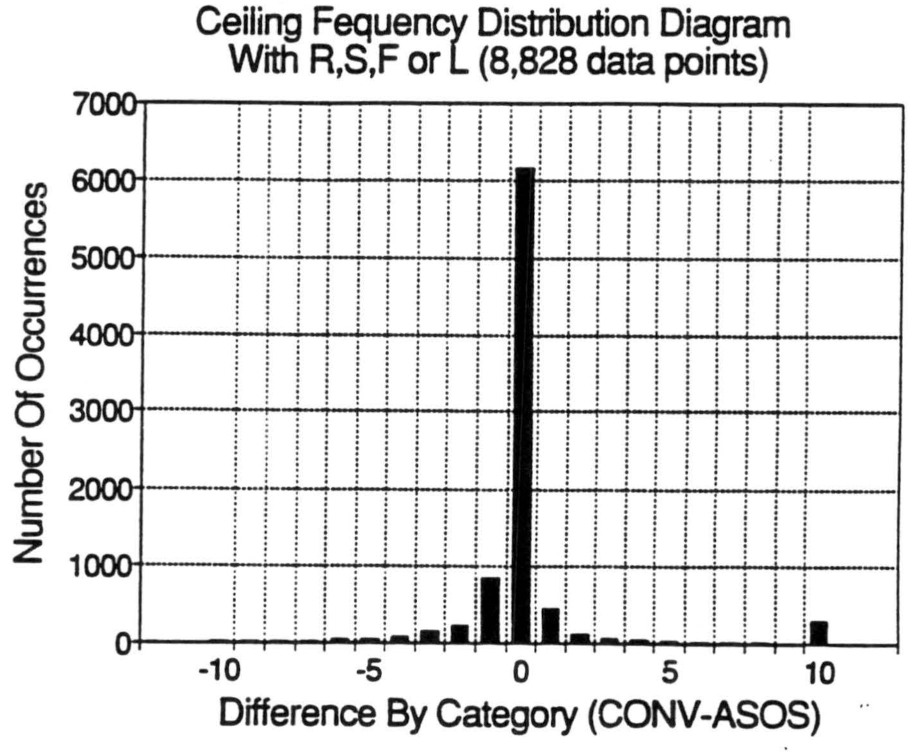


Figure 4.3.1. Scatter and frequency distribution diagram for when rain snow fog or drizzle was reported.

4.4 CONDITIONS FOUND IN THE OBSERVATIONS WHEN DISCREPANCIES OCCURRED

Table 4.4.1 shows the number of conventional observations that are reporting either rain, snow, fog, or drizzle, and have a corresponding ASOS ceiling five or more categories lower than the conventionally reported ceiling. This is represented by the 463 events listed in categories 5, 6, 7, 8, 9, and 10 in fig 4.3.1.

Table 4.4.1. Distribution of weather elements when ASOS reports ceilings five or more categories lower than CONV reports.

Weather Type	Number of Events
Snow	18
Rain	71
Fog	343
Drizzle	31
Total events	463

One explanation that can account for the high frequency when fog is occurring is a geometrically low threshold for the first detection of a cloud base by the ASOS ceilometer algorithm. If the ceilometer gets a very early return off of the fog droplets, it may interpret this as a cloud base. When a human observer can see stars at night and halos around street lights, he or she is likely to report a clear sky and some obstruction to visibility due to Fog. The ASOS algorithm will surely pick up the visibility reduction, by coupling it to the temperature/dewpoint spread and report Fog.

Figure 4.4.1 may support the idea of an excessively low threshold as indication of a cloud base. This frequency distribution diagram was generated from a scatter diagram depicting a small number of occurrences (115 events) of blowing sand (BN), blowing snow (BS), and/or blowing dust (BD). These phenomena are conventionally reported weather elements that involve some aerosol in the lower 50 feet of the atmosphere. As such, it appears that the grouping of occurrences on the right hand side of Fig. 4.4.1 illustrates the tendency for the ASOS ceilometer to report a cloud base at much lower heights, so as to include blowing phenomena.

When the ASOS LEDWI is reporting snow the occurrence of a very low cloud base due to reflected returns close to the ground appears to a lesser extent. Fig. 4.4.2 was generated by evaluating all occurrences (730 events) in which the ASOS LEDWI reported snow, and or snow with fog. Both phenomena introduces good reflective targets close to the ground for interpretation by the ceilometer algorithm as being a cloud base.

The opposite occurrence has also happened in which the conventional ceiling was reported to be 5 or more categories lower than the ASOS ceiling. Fig. 4.4.3 a, b, c show small populations of data 5 or more categories higher than conventionally reported ceilings of less than or equal to 5,000 feet, less than or equal to 3,000 feet and less than or equal to 1,000 feet respectively. These populations are equally split between rain and fog occurrences as illustrated in table 4.4.2. No simple relation exists to categorize these occurrences but possible relations may point to differences in spatial averaging done by the observer and time averaging done by ASOS.

Ceiling Scatter Diagram

Ceiling	Scatter	Cat.	(Flight	level)							Total
≤010	≤020	≤030	≤040	≤050	≤060	≤070	≤080	≤090	≤100	≥110	
22	1	0	0	0	0	0	0	0	0	4	27
17	20	2	2	1	0	0	0	0	0	1	43
7	6	4	0	0	0	0	0	0	0	4	21
2	1	0	2	0	0	0	0	0	0	0	5
1	1	0	3	2	0	0	0	0	0	0	7
0	0	0	0	0	2	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	10	10
49	29	6	7	3	2	0	0	0	0	19	115

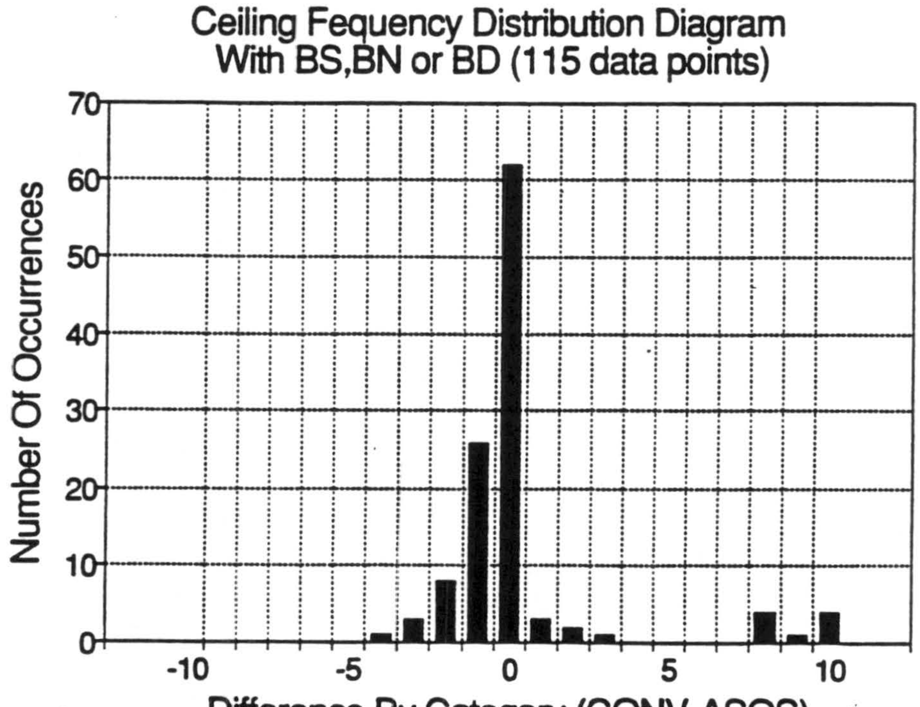


Figure 4.4.1. Scatter and frequency distribution diagram when blowing phenomena is present.

Ceiling Scatter Diagram

Ceiling	Scatter	Cat.	Flight	level)							Total
≤010	≤020	≤030	≤040	≤050	≤060	≤070	≤080	≤090	≤100	≥110	
206	18	3	1	0	0	0	0	0	0	5	233
75	112	15	3	3	2	0	0	0	0	3	213
29	34	41	0	8	2	1	0	0	0	29	144
7	3	5	18	2	0	1	1	0	0	1	38
5	5	3	12	16	0	0	1	0	0	0	42
2	1	0	1	4	10	1	0	0	0	0	19
1	1	3	0	1	3	3	1	0	0	0	13
0	1	0	1	1	1	0	1	1	0	0	6
0	0	1	0	0	1	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	1	0	1
0	0	0	1	0	0	1	0	0	0	17	19
325	175	71	37	35	19	7	4	1	1	55	730

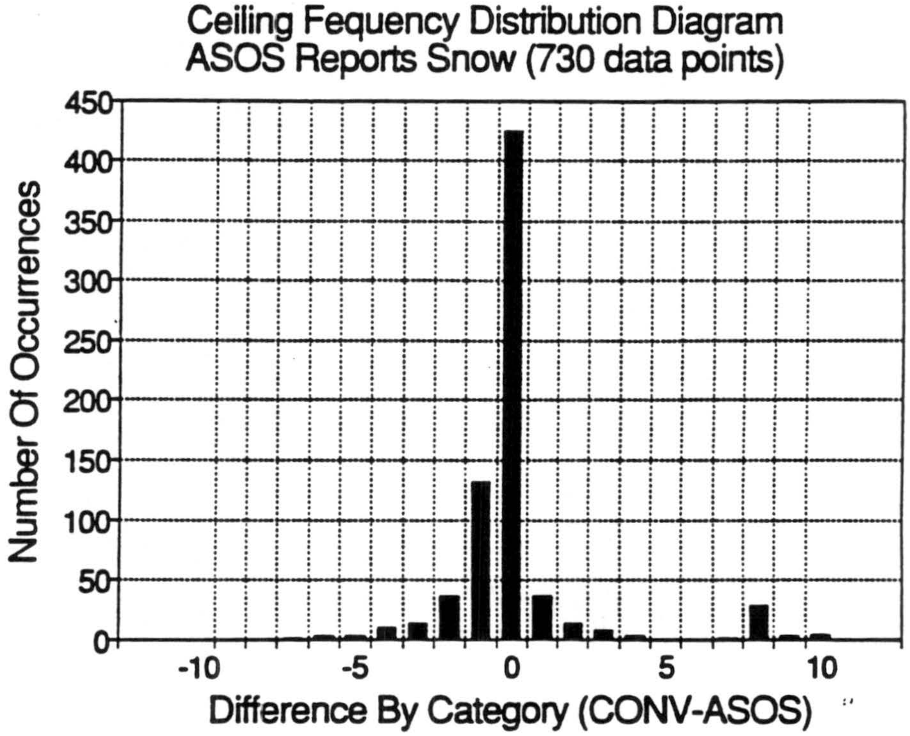


Figure 4.4.2. Scatter and frequency distribution diagrams for events when ASOS reports snow.

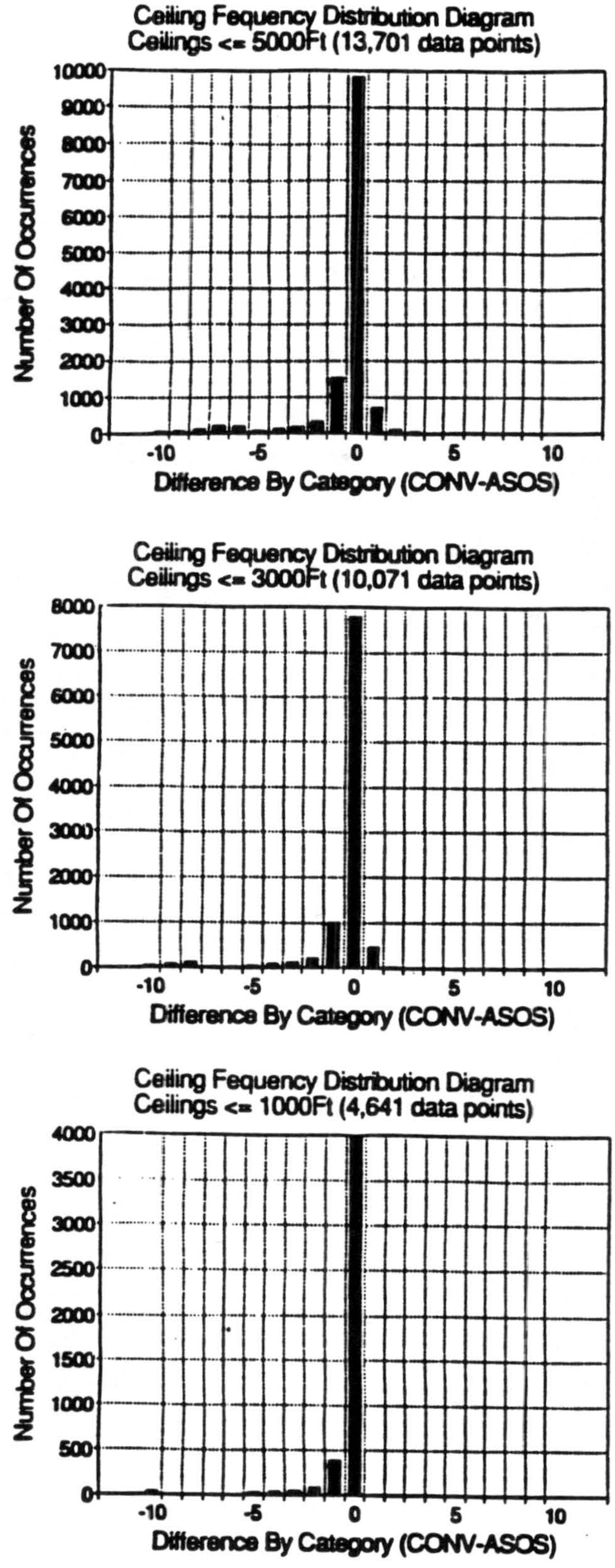


Figure 4.4.3. Frequency distribution diagrams for CONV ceilings below 5000 ft, 3000 ft, and 1000 ft.

Table 4.4.2. Distribution of weather elements when ASOS is reporting a ceiling five or more categories higher than CONV reports

Weather Type	Number of Events
Snow	13
Rain	117
Fog	96
Drizzle	3
Total events	229

5.0 COMPARISON OF VISIBILITY

The comparison of visibility is different in that the conventional tool used was the human eye, and a trained interpretation of the atmosphere surrounding the observer. there is no historical use of instrumentation to determine visibility, and an instrumented future visibility determination will be a significant change in both technique and interpretation.

The introduction of Runway Visual Range or RVR brought instrumentation into the forefront as an interpretive way to estimate visibility. RVR consists of transmissometers spaced strategically along the runways of major airports. The RVR outputs a value of transmissivity, that is often interpreted as a visibility. In the SAO code, RVR reports are sometimes included in the remarks sections, which this investigation has chosen to ignore for reasons mentioned in section 3.4.2. Under the forecasting guidelines used by the U. S. Air Force, RVR is not a forecastable weather element, whereas visibility can, and is forecast regularly.

The major difference between ASOS and conventional techniques is time averaging versus spatial averaging and point values versus prevailing conditions. There are remarkable similarities in reports which can only be attributed to the high degree of technical achievements and latest understandings in the field of optics. There are equally a few consistent disparities that indicate the limits of current technology and may also indicate optical phenomena that has yet to be investigated. In either case, experience with transmissometers will not necessarily prove helpful in this transition, as neither they nor any other 'line of sight' or point value instrument can provide the spacial averaging or prevailing visibility frequently requested by the FAA.

5.1 METHODOLOGY

A scatter diagram was used to evaluate the reported visibility from the ASOS instrument and the human Observer. From the scatter diagram, a frequency distribution diagram was made by summing the diagonals along the scatter diagram on either side of the diagonal that represents equivalency. Fig. 4.1.1 reproduced here as Fig. 5.1.1 illustrates the method used to account for multiple events and to illustrate the frequency of similar events occurring.

Across the top of the scatter diagram is the reported visibility values produced by conventional observations. Along the side is the corresponding values produced by ASOS. The categories used to group visibilities are the standard reportable increments that ASOS uses, so conventionally observed visibilities had to be adjusted to match the reportable increments used in the ASOS algorithm. for instance, a conventionally reported visibility of 100 miles was adjusted so it would coincide with the ASOS category of 10+. The adjustment schedule is listed as Table 5.1.1.

If for a particular event, the conventional reported visibility fell into category 10 and the ASOS reported visibility also fell into category 10, an incremental "hit" would be added to the cell of the scatter diagram at the intersection of the two categories. The diagonal that runs from the upper left hand corner to the lower right corner represents the equivalency of observations or hits. The region to the upper right of this diagonal indicates the ASOS reported values are one or more reportable increments lower than the CONV reported category. The region to the lower left of the equivalency diagonal indicate the ASOS reported values are one or more reportable increments higher than CONV values. All comparisons of visibility are with respect to the conventional values.

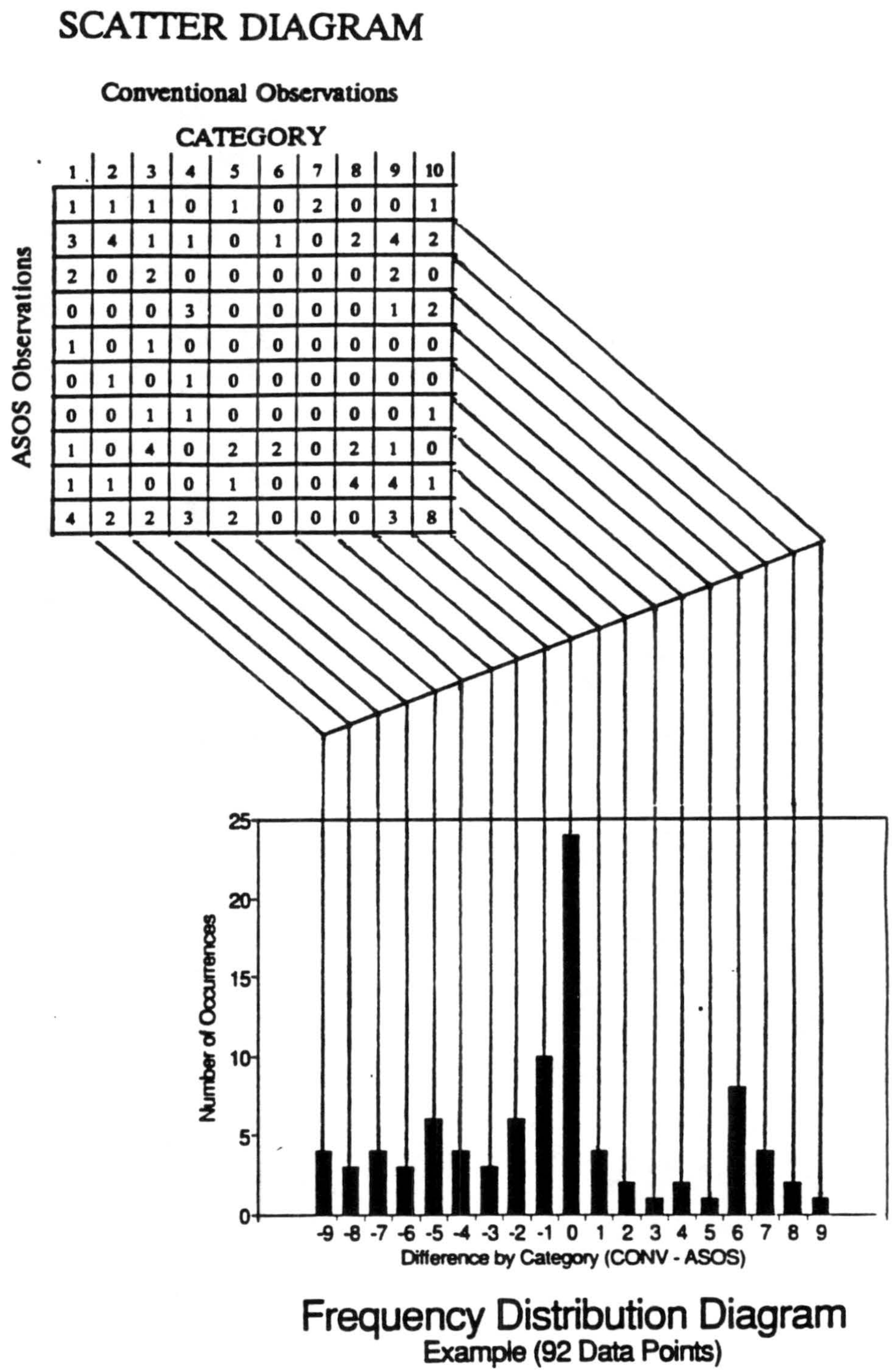


Figure 5.1.1. Example of a scatter and frequency distribution diagram.

Table 5.1.1. Visibility Categories

(Values in Statute Miles)

Conventional Range	ASOS Range[1]	Category in this Study
0.00 - 0.24	<0.25	Cat 1
0.25	0.25	Cat 2
0.26 - 0.50	0.50	Cat 3
0.55 - 0.75	0.75	Cat 4
0.80 - 1.00	1.00	Cat 5
1.05 - 1.25	1.25	Cat 6
1.30 - 1.50	1.50	Cat 7
1.55 - 1.75	1.75	Cat 8
1.80 - 2.00	2.00	Cat 9
2.05 - 2.50	2.50	Cat 10
2.55 - 3.00	3.00	Cat 11
3.05 - 3.50	3.50	Cat 12
3.55 - 4.00	4.00	Cat 13
5.00 - 6.00	5.00	Cat 14
7.00 - 9.00	7.00	Cat 15
10.00 - 10.0+	10+	Cat 16

1. ASOS USERS GUIDE (Aug 1991)

The frequency distribution diagram is obtained by summing up the diagonals. This diagram provides a visual representation of the frequency with which a comparison occurs. Like the scatter diagram, the left hand side of the frequency distribution diagram shows the number of occurrences in which the ASOS values are higher than the corresponding CONV reported values of visibility. This diagram is a convenient single representation of the comparison in visibility reports for different weather phenomena or other selective criteria in which an evaluation can be made.

5.2 OVERALL COMPARISON

Using the total number of matched pair, 63,533 data points, 81.8% were "hits" while 93.7% were within one reportable category (59,517 data points). Fig. 5.2.1 shows the complete scatter diagram and Frequency distribution diagram for all the data.

Once again, the vast majority of data occurs in the last category, and equates ASOS visibility with conventional visibility. This last category illustrates the percentage of fair weather days which occurred during the precommissioning period. Nearly 80.1% of the observations were reporting visibility in the 10+ ASOS category.

5.3 COMPARISON BY WEATHER PHENOMENA

There were 9,322 events where weather was reported of which 2,647 (28.4%) were "hits" while 60.8% were within ±1 reportable increment. There were 8,702 matched pairs of visibility reports in which the conventional SAO also reported rain, snow, fog, or drizzle. This accounts for 13.7% of the total visibility data. Fig. 5.3.1 shows the complete scatter diagram and frequency distribution diagram for this subset of the total population with conventionally reported rain, snow, fog, or drizzle.

The striking difference between this figure and Fig. 5.2.1 is the spread of occurrences around the equity value. The distribution of non-equal values seems skewed slightly to the left, which may indicate that ASOS reports values higher than CONV. Further investigation into the events that generated visibility discrepancies of five or more reportable increments lead to the appearance of a "high end" bias during low visibility events.

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
101	19	1	0	0	0	0	0	0	0	0	0	0	2	0	4	127
104	70	19	4	2	0	1	0	1	1	3	0	3	3	0	8	219
50	45	89	13	6	0	5	0	2	0	2	0	0	2	3	12	229
18	24	75	27	10	1	4	2	1	1	6	0	3	3	4	9	188
6	9	47	49	27	5	10	0	3	1	3	0	4	4	2	10	180
0	4	37	41	44	8	17	0	10	2	4	0	3	2	3	10	185
2	7	26	17	41	9	35	3	19	4	7	0	4	3	2	1	180
0	3	21	25	53	7	49	7	33	9	16	0	4	4	6	10	247
2	4	18	25	49	6	60	7	69	25	43	0	18	6	6	15	353
3	2	5	10	56	13	56	8	99	47	64	0	31	26	11	21	452
2	1	6	8	44	6	50	11	84	58	123	0	64	45	13	21	536
0	1	3	7	11	2	45	1	80	58	135	1	94	59	32	19	548
0	0	4	4	14	3	22	2	79	69	209	0	160	196	84	39	885
1	0	3	2	14	2	22	0	65	51	244	0	265	619	341	157	1786
0	0	5	3	5	0	11	0	21	24	104	0	164	808	1299	1160	3604
5	5	7	2	5	2	4	0	16	9	36	0	71	563	3813	49276	53814
294	194	366	237	381	64	391	41	582	359	999	1	888	2345	5619	50772	63533

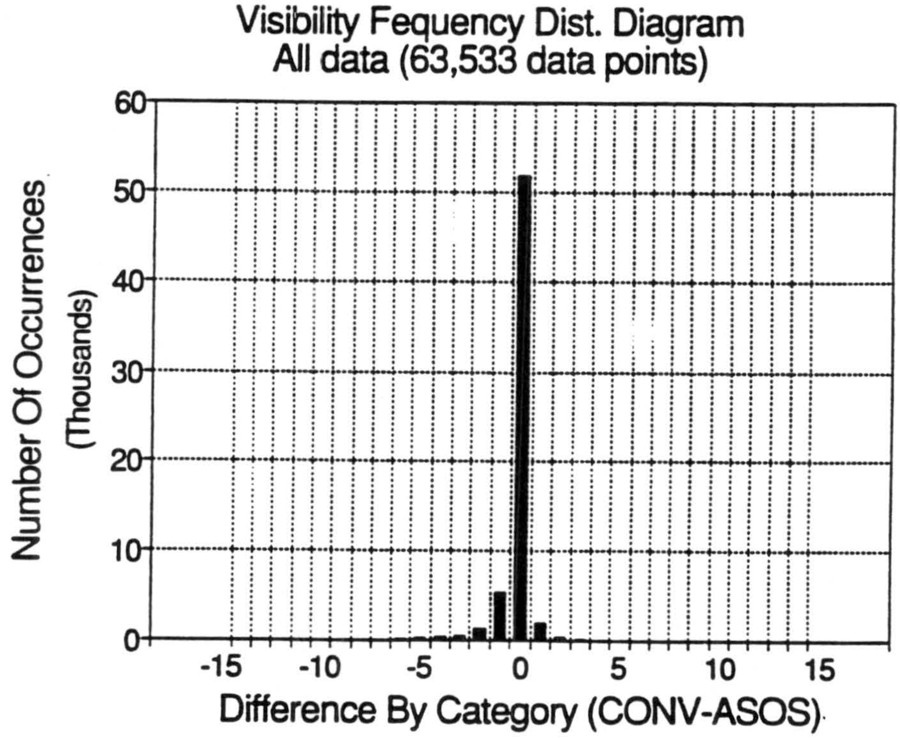


Figure 5.2.1 Scatter and frequency distribution diagram for all visibility data.

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
101	19	1	0	0	0	0	0	0	0	0	0	0	2	0	0	123
104	63	19	4	2	0	1	0	1	1	3	0	3	3	0	1	205
50	45	87	13	6	0	5	0	2	0	2	0	0	2	0	0	212
18	24	75	27	10	1	4	2	1	1	6	0	3	3	1	0	176
6	9	47	49	27	5	10	0	3	1	3	0	4	4	1	1	170
0	4	37	41	44	8	17	0	10	2	4	0	3	2	0	2	174
2	7	26	17	41	9	35	3	19	4	7	0	4	3	1	1	179
0	3	21	25	53	7	49	6	33	9	16	0	4	4	2	1	233
2	4	18	25	49	6	60	7	67	25	43	0	18	6	2	0	332
3	2	5	10	56	13	56	8	99	46	63	0	31	24	4	5	425
2	1	6	8	44	6	50	11	84	57	122	0	63	44	4	5	507
0	1	3	7	11	2	45	1	80	56	131	1	91	52	14	7	502
0	0	4	4	14	3	22	2	79	66	204	0	156	179	43	11	787
1	0	3	2	14	2	22	0	62	50	233	0	240	549	73	30	1281
0	0	5	3	5	0	11	0	20	24	102	0	153	693	355	374	1745
5	5	7	2	5	2	4	0	14	9	34	0	70	452	287	755	1651
294	187	364	237	381	64	391	40	574	351	973	1	843	2022	787	1193	8702

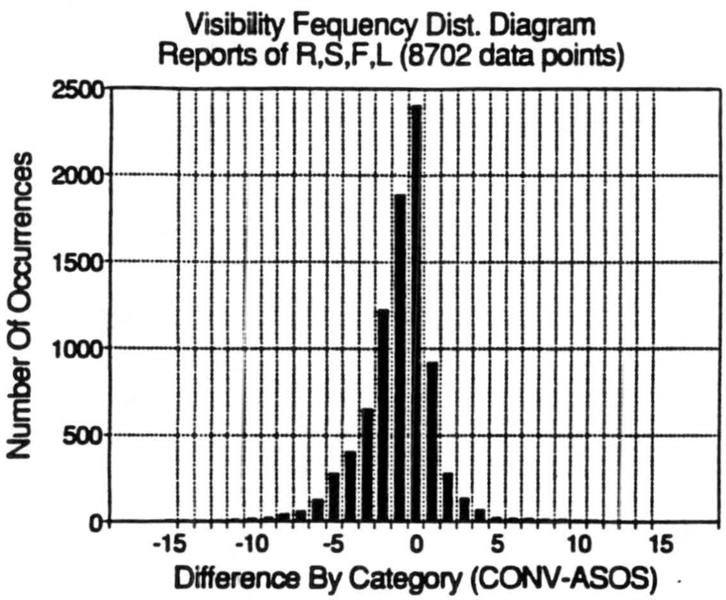


Figure 5.3.1. Scatter and frequency distribution diagram for CONV reports of rain, snow, fog, and drizzle.

Fig. 5.3.2 shows the complete scatter diagram and frequency distribution for the population of data (3908 events) in which the conventional visibility values are 3.0 miles or less which supports the idea of a high end bias in low visibility events.

5.4 CONDITIONS FOUND IN THE OBSERVATIONS WHEN DISCREPANCIES OCCURRED

Working under the suspicion that ASOS may report higher visibility values during low visibility events, an evaluation of the population of 1,536 data points in which the conventional values were less than 1¼ miles was performed. Fig. 5.4.1 is the result of that evaluation.

This diagram clearly illustrates a skewed appearance, but one must remember that the nature of the frequency diagram does not permit values to appear above the "five categories lower" diagonal. At visibilities of 1¼ mile or less, each reportable increment is ¼ mile, and as the frequency distribution diagram illustrates, this would translate to a ½ to ¾ mile positive bias on the part of the ASOS instrument. Another evaluation was performed on the population of conventional visibility values between 1½ - 1¾; 2 - 2½; and 3 - 3½ miles. These ranges were picked to match the ranges in which the ASOS visibility instrument was compared to standard NWS transmissometers (DOC 91). Fig. 5.4.2 shows the results of these three evaluations. It is clear that comparisons of instruments with instruments cannot match the comparison of instruments with human observers.

An investigation into the weather phenomena most prevalent during these events began with the most variable and likely to behave in this way, namely shower activity. It would lead one to believe that spatial averaging and time averaging would have greatest

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
101	19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	121
104	70	19	4	2	0	1	0	1	1	3	0	0	0	0	0	205
50	45	89	13	6	0	5	0	2	0	2	0	0	0	0	0	212
18	24	75	27	10	1	4	2	1	1	6	0	0	0	0	0	169
6	9	47	49	27	5	10	0	3	1	3	0	0	0	0	0	160
0	4	37	41	44	8	17	0	10	2	4	0	0	0	0	0	167
2	7	26	17	41	9	35	3	19	4	7	0	0	0	0	0	170
0	3	21	25	53	7	49	7	33	9	16	0	0	0	0	0	223
2	4	18	25	49	6	60	7	69	25	43	0	0	0	0	0	308
3	2	5	10	56	13	56	8	99	47	64	0	0	0	0	0	363
2	1	6	8	44	6	50	11	84	58	123	0	0	0	0	0	393
0	1	3	7	11	2	45	1	80	58	135	0	0	0	0	0	343
0	0	4	4	14	3	22	2	79	69	209	0	0	0	0	0	406
1	0	3	2	14	2	22	0	65	51	244	0	0	0	0	0	404
0	0	5	3	5	0	11	0	21	24	104	0	0	0	0	0	173
5	5	7	2	5	2	4	0	16	9	36	0	0	0	0	0	91
294	194	366	237	381	64	391	41	582	359	999	0	0	0	0	0	3908

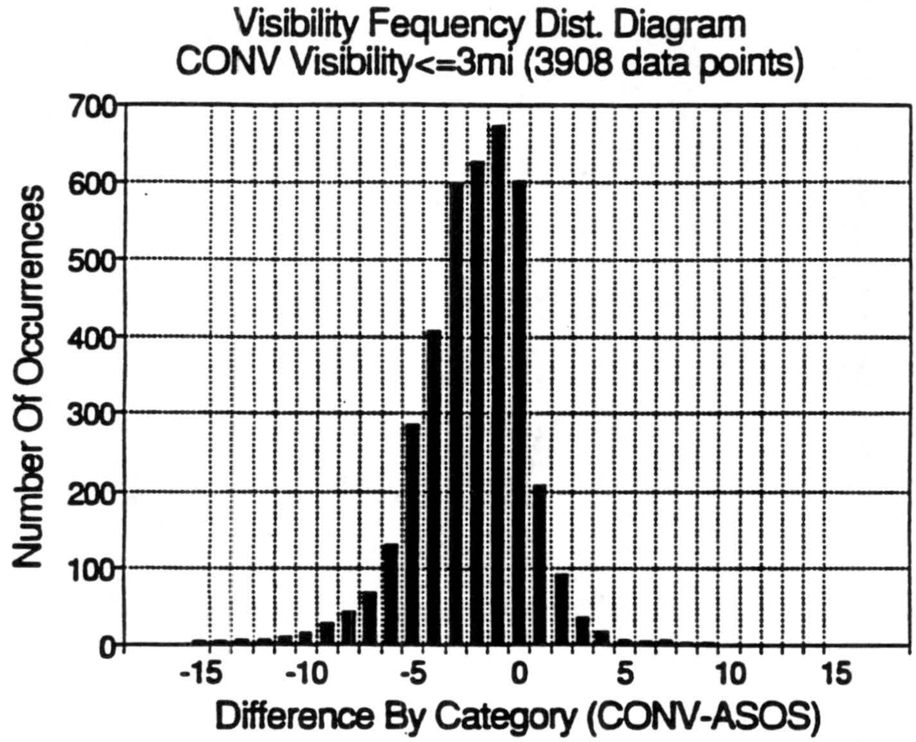


Figure 5.3.2. Scatter and frequency distribution diagram for visibilities of three miles or less.

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
101	19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	121
104	70	19	4	2	0	0	0	0	0	0	0	0	0	0	0	199
50	45	89	13	6	0	0	0	0	0	0	0	0	0	0	0	203
18	24	75	27	10	1	0	0	0	0	0	0	0	0	0	0	155
6	9	47	49	27	5	0	0	0	0	0	0	0	0	0	0	143
0	4	37	41	44	8	0	0	0	0	0	0	0	0	0	0	134
2	7	26	17	41	9	0	0	0	0	0	0	0	0	0	0	102
0	3	21	25	53	7	0	0	0	0	0	0	0	0	0	0	109
2	4	18	25	49	6	0	0	0	0	0	0	0	0	0	0	104
3	2	5	10	56	13	0	0	0	0	0	0	0	0	0	0	89
2	1	6	8	44	6	0	0	0	0	0	0	0	0	0	0	67
0	1	3	7	11	2	0	0	0	0	0	0	0	0	0	0	24
0	0	4	4	14	3	0	0	0	0	0	0	0	0	0	0	25
1	0	3	2	14	2	0	0	0	0	0	0	0	0	0	0	22
0	0	5	3	5	0	0	0	0	0	0	0	0	0	0	0	13
5	5	7	2	5	2	0	0	0	0	0	0	0	0	0	0	26
294	194	366	237	381	64	0	0	0	0	0	0	0	0	0	0	1536

Visibility Fequency Dist. Diagram
Visibility <=1.25mi (1,536 data points)

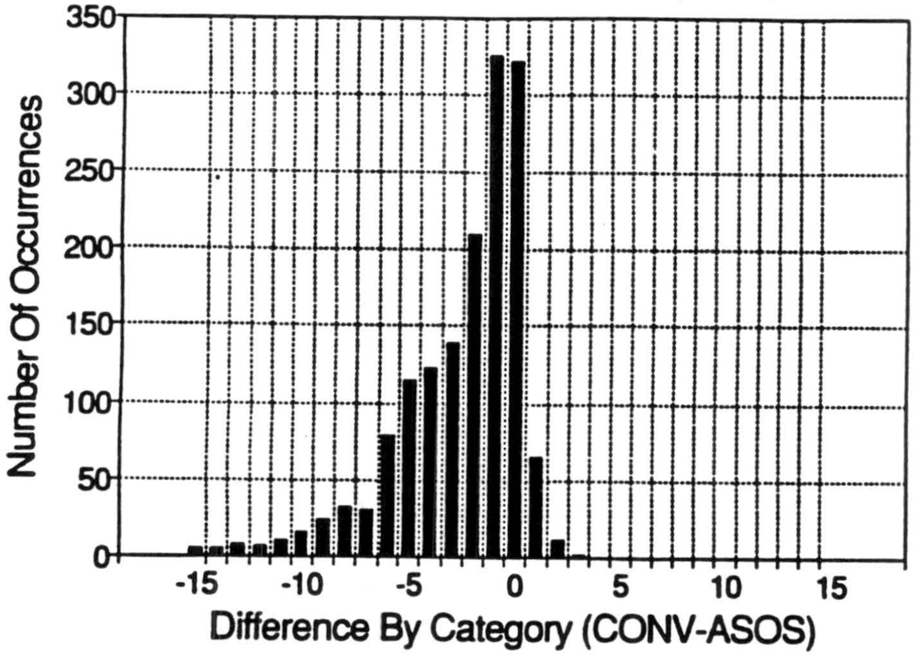


Figure 5.4.1. Scatter and frequency distribution diagrams for visibilities of 1¼ miles or less.

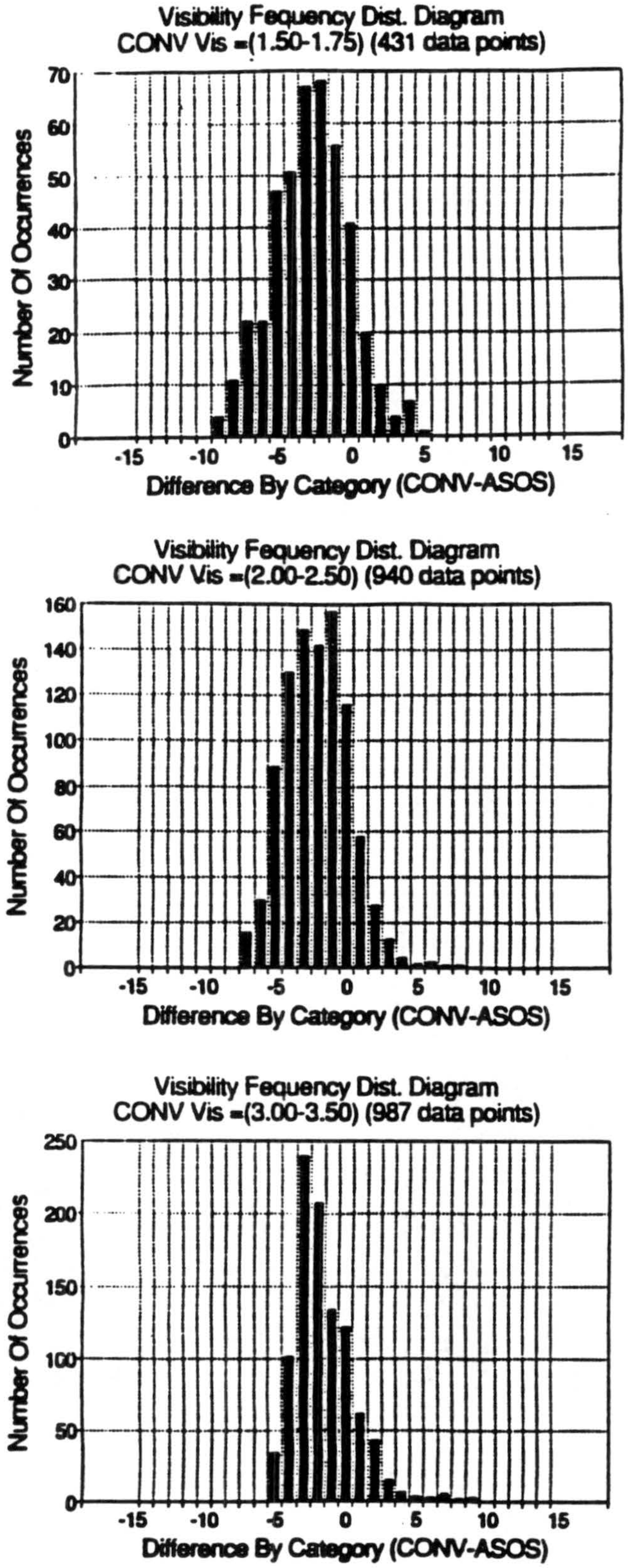


Figure 5.4.2. Frequency distribution diagrams for CONV visibility in the ranges of 1½ - 1¾ miles, 2 - 2½ miles, and 3 - 3½ miles.

incompatibilities in phenomena with short duration and limited coverage. Fig. 5.4.3 shows the results of evaluating the 1,698 events in which snowshowers, thundershowers, or rainshowers were occurring. It is evident that the ASOS algorithms performed fairly well in evaluating visibility in showers.

Blowing phenomena was also evaluated, but the small population size doesn't statistically amount to any significant findings. Fig. 5.4.4 illustrates the visibility evaluation for 115 cases of blowing phenomena.

An evaluation of events in which the ASOS LEDWI reported fog, rain or snow was performed. Instead of employing the usual conventional reporting of fog, rain, or snow, it was decided to use the ASOS determination of precipitation type (from the ASOS LEDWI) just in case there were differing calibration variables within the ASOS algorithm. As Burnham (1993) points out, scattering geometry is different in the three aerosols and when applied in three dimensional space, these differences will bias a forward scattering visibility meter calibrated for Fog alone. Fig. 5.4.5 illustrates the frequency distribution diagrams for fog, rain, and snow respectively.

Clearly Snow has the greatest range of scattering geometries possible, it also produces the greatest variation in reported visibility values.

Kenneth Kraus (1993) studied the comparison of ASOS visibility with human visibility under low cloud cover and found an optical phenomena that may result in human visibility values lower than ASOS values by virtue of low cloud and gray horizons giving the impression of poorer conditions.

Although this investigation didn't deal with the low ceiling values that Kraus studied, an evaluation of visibility when ceilings were below 5,000 feet, 3,000 feet, and 1,000 feet was performed. Figure 5.4.6 shows the results of evaluating these three events. The bias clearly

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
0	0	3	1	1	0	1	0	0	0	0	0	0	0	0	0	6
0	2	3	1	1	0	1	1	0	0	3	0	0	0	1	0	13
0	0	0	0	3	1	1	0	1	0	0	0	3	2	0	1	12
0	0	2	4	3	0	1	0	2	1	0	0	1	1	0	2	17
0	0	1	1	4	0	1	0	5	2	5	0	2	1	1	1	24
0	0	1	1	2	0	3	0	5	3	2	0	0	0	2	1	20
0	0	0	0	2	0	10	1	5	2	5	0	5	5	2	0	37
0	0	0	0	2	0	1	1	14	6	10	0	5	10	3	3	55
0	0	1	0	2	2	0	0	9	2	15	0	12	11	2	4	60
0	0	0	0	1	0	0	0	4	4	8	0	13	6	10	7	53
0	0	0	0	0	0	1	0	6	10	12	0	14	28	22	8	101
0	0	0	0	2	1	2	0	3	6	16	0	14	58	44	23	169
0	0	0	0	0	0	0	0	1	3	8	0	12	79	202	267	572
0	0	0	0	0	0	0	0	2	0	1	0	1	19	106	427	556
0	4	11	8	23	4	22	3	57	39	85	0	82	22	395	745	1698

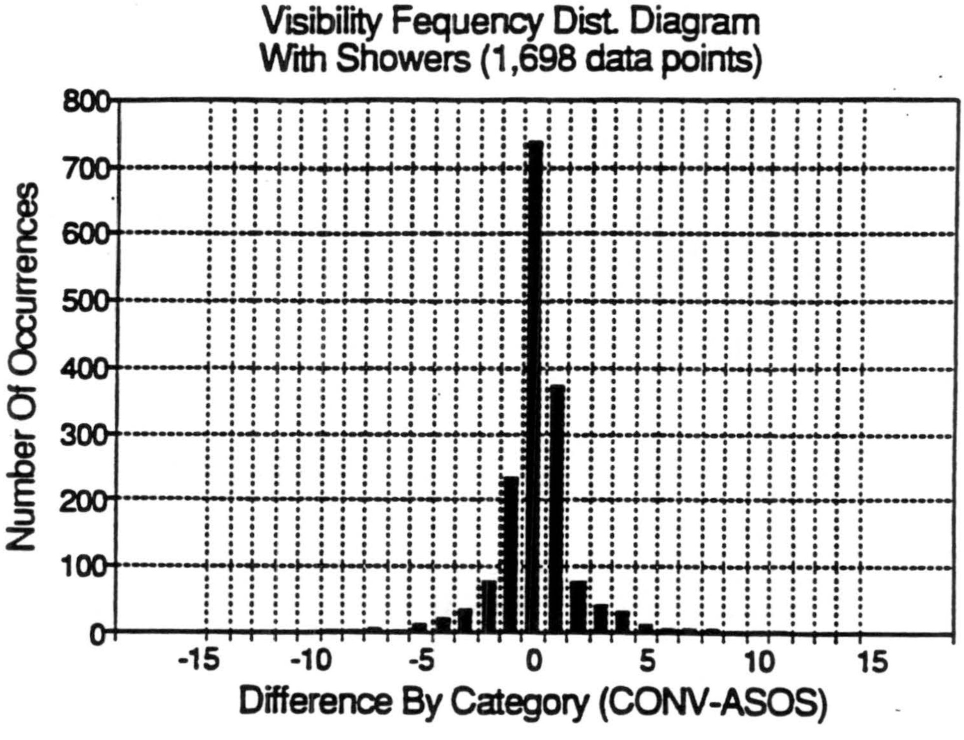


Figure 5.4.3. Scatter and frequency distribution diagram for when shower activity was occurring.

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6	3	6	0	0	0	1	0	0	0	0	0	0	0	0	0	16
0	3	4	2	0	0	1	0	0	0	0	0	0	0	0	0	10
2	1	8	7	3	0	1	0	0	0	1	0	1	0	0	0	24
0	0	4	1	2	0	0	0	0	0	0	0	0	0	0	0	7
0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	4
0	1	1	0	1	0	0	0	0	1	0	0	0	1	0	0	5
0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	4
0	0	1	2	2	1	1	0	1	0	0	0	0	1	0	0	9
0	0	0	0	0	0	0	0	1	0	3	0	1	0	0	0	5
0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	3
0	0	0	0	0	0	1	0	0	0	1	0	1	3	0	0	6
0	0	0	0	0	0	0	0	1	1	2	0	2	9	0	0	15
9	9	26	14	9	1	7	0	6	3	10	0	6	15	0	0	115

Visibility Fequency Dist. Diagram
CONV Reported BS,BN,BD(115 data points)

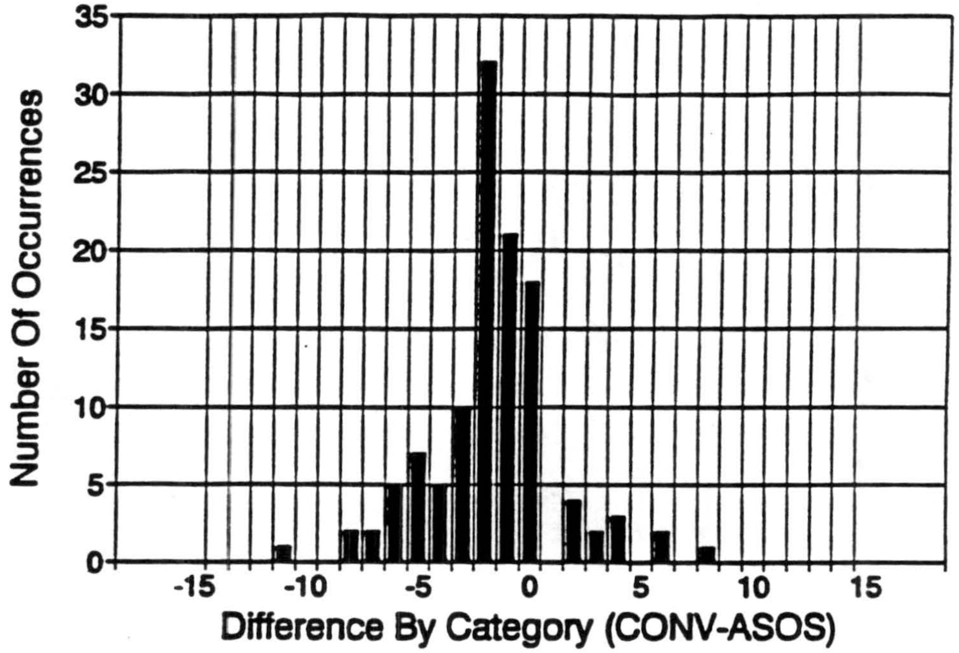


Figure 5.4.4. Scatter and frequency distribution diagram for events in which blowing phenomena were present.

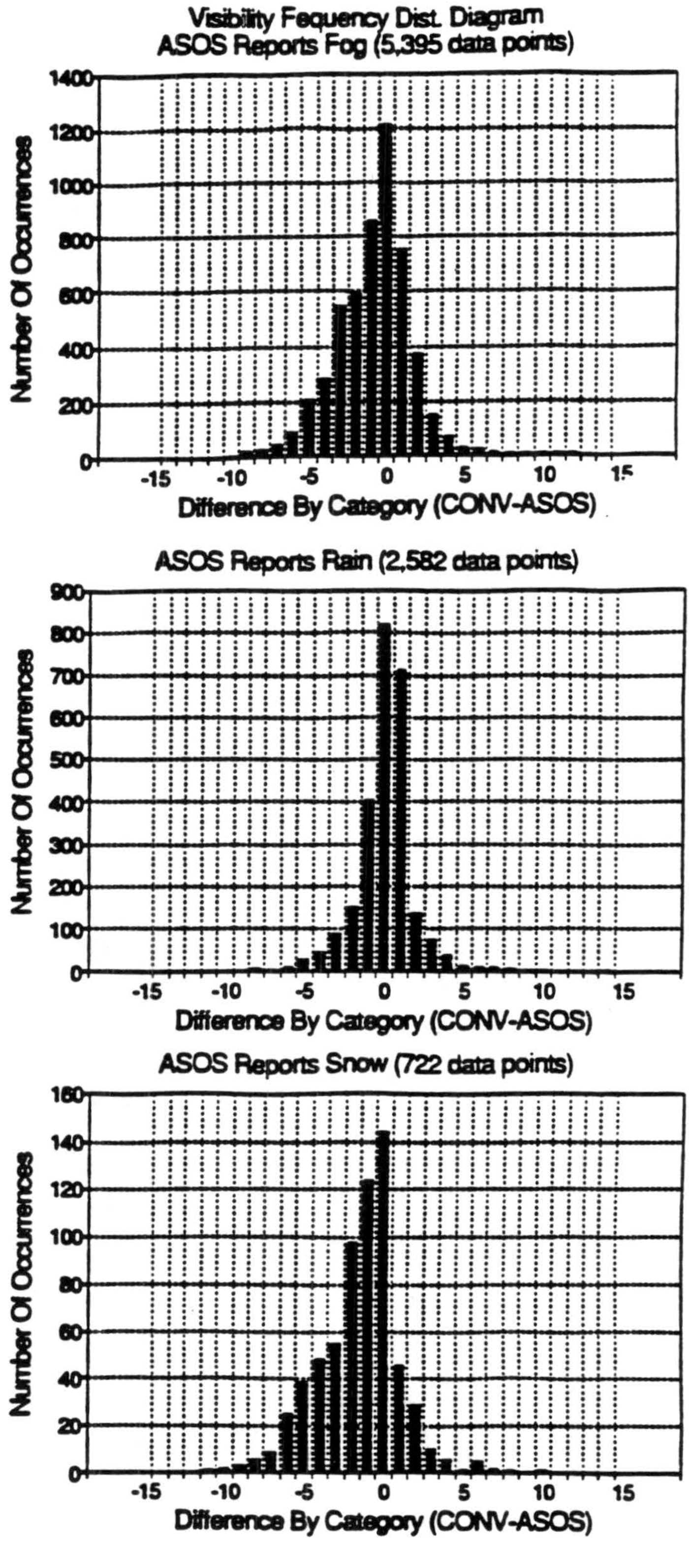


Figure 5.4.5. Frequency distribution diagram when ASOS reports fog, rain, or snow.

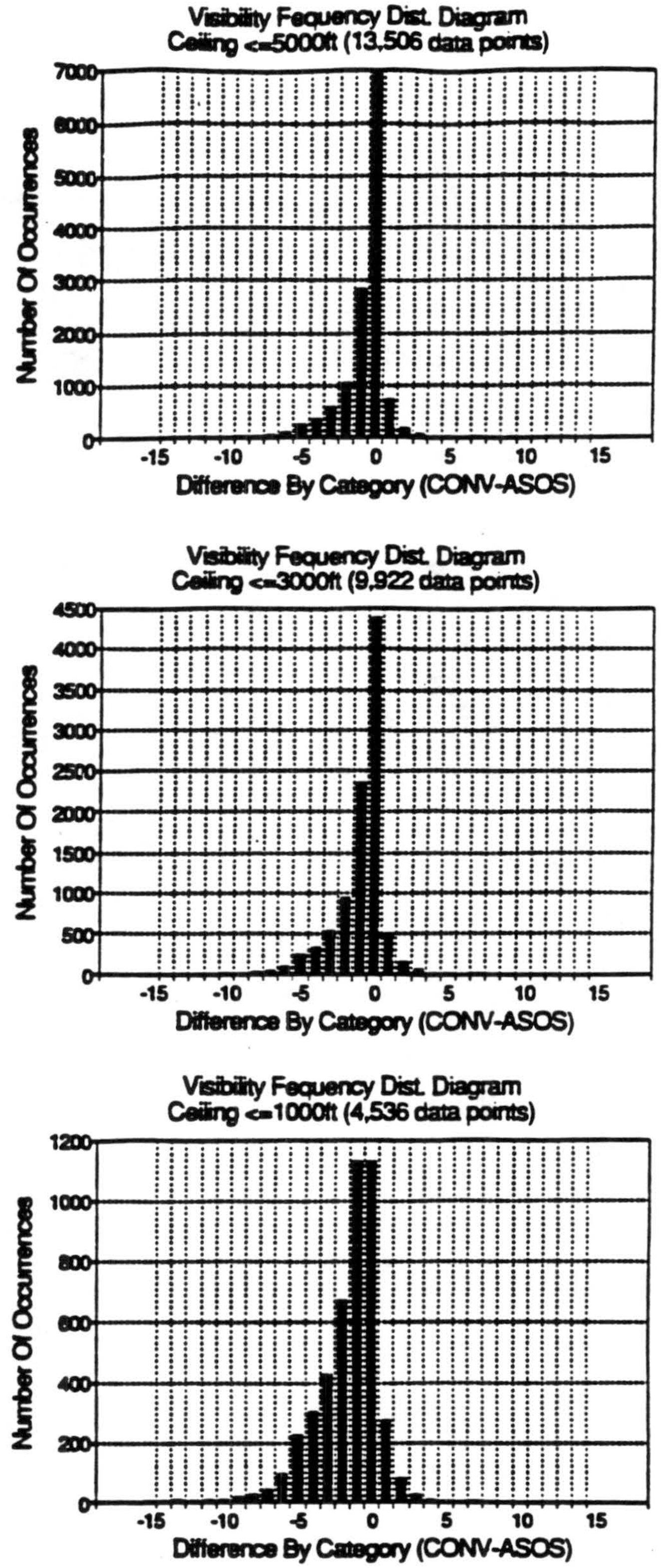


Figure 5.4.6. Frequency distribution diagrams for when CONV ceilings were reported at or below 5,000 ft; 3,000 ft; and 1,000 ft.

increases in events where the ceiling is 1,000 feet or less, thus supporting Kraus's claim of a significant difference in automated visibility and conventional visibility with respect to ceiling conditions.

6.0 COMPARISON IN CONVENTIONALLY OBSERVED IFR

Aircraft must be flown in accordance with instrument flight rules which also dictate different physical spacings between aircraft when weather conditions are considered to be IFR. Fuel requirements become more rigid when flying in IFR weather and each aircraft must carry excess fuel, enough for an approach and then a leg to an alternate airfield and landing minimums for that airfield must be loaded onto the plane.

Should the modernization program of the NWS produce more reports of IFR weather, then millions of dollars of excess expenditures associated with unnecessary requirements may drive the aviation industry to question the accuracy of the instrument making the observation. By selecting only those observations with IFR conditions (ceilings equal or greater to 200 feet but less than 1,000 feet, and/or visibility equal to or greater than 1/2 mile but less than three miles) an evaluation of this critical weather regime was investigated.

6.1 TOTAL IFR COMPARISON

There were 5,263 matched pairs of conventionally reported IFR. In keeping with the methodology of this investigation, a two category scatter diagram was generated. Conventional categories across the top are either IFR or not IFR, along the side are the similar ASOS categories. Fig. 6.1.1 shows the results of the available IFR events.

The first consideration is the total number of IFR events. ASOS reported 5,129 IFR events while CONV reported 5,263 IFR events. This is not a significant difference, being only 2.5%. The second important conclusion is the relative balance in the two error

IFR Category Comparison
(events)

CONV IFR (5,263)	CONV NOT IFR (58,952)	
4,499	630 Type I Error	ASOS IFR (5,129)
764 Type II Error	58,322	ASOS NOT IFR (59,086)

IFR is defined as visibility ≥1/2 mile but <3 miles and/or ceiling ≥200ft but <1,000ft.

Figure 6.1.1. Two category scatter diagram for IFR or Non-IFR conditions.

categories; those being type I: Reporting IFR when IFR is not warranted, and type II: Not reporting IFR when IFR is warranted. The balance indicated by 630 Type I errors and 764 type II errors would suggest that the ASOS instruments are not likely to indicate a bias in the determination of IFR weather events.

6.2 COMPARISON OF CEILING OBSERVATIONS IN IFR WEATHER

Evaluating the 5,263 conventionally reported IFR weather events will give some indication of the performance of the ASOS Ceilometers under conditions most critical to aviation. All categories remain the same as in other evaluations. Fig. 6.2.1 shows the results of this evaluation.

The population of 79 events on the extreme right of the frequency distribution diagram once again illustrates the problems of conventionally reporting fog and clear skies,

Ceiling Scatter Diagram

Ceiling	Scatter	Cat.	((Flight	level)							Total
≤010	≤020	≤030	≤040	≤050	≤060	≤070	≤080	≤090	≤100	≥110	
3597	33	5	3	2	0	0	0	0	1	79	3720
287	148	12	5	2	1	1	0	0	0	1	457
77	31	40	5	3	1	4	2	0	0	1	164
41	11	9	21	6	2	0	0	0	1	0	91
41	4	6	11	27	3	1	1	0	0	0	94
30	3	1	2	3	8	2	1	0	0	0	50
6	0	2	0	0	5	3	1	0	0	1	18
3	0	0	2	0	2	0	3	0	0	2	12
3	0	2	0	0	0	0	2	3	2	0	12
3	0	1	0	0	0	0	1	0	3	0	8
35	3	1	2	1	2	0	2	1	2	126	175
4123	233	79	51	44	24	11	13	4	9	210	4801

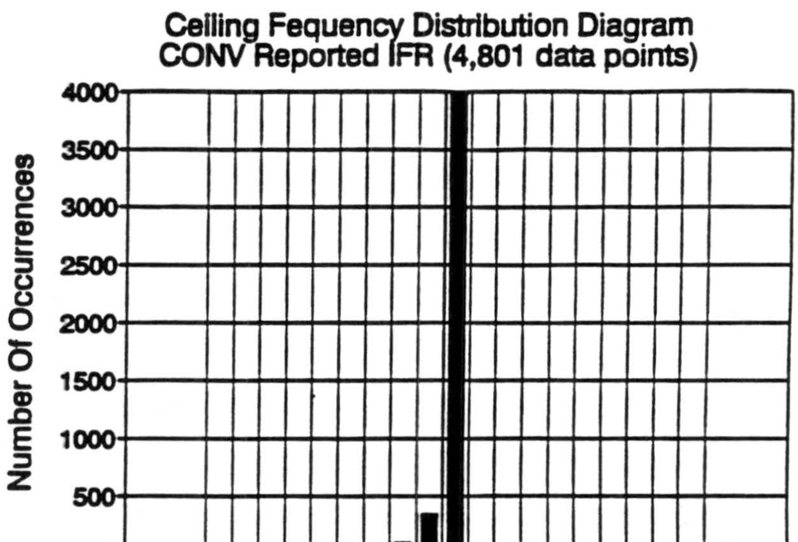


Figure 6.2.1. Scatter and frequency distribution diagram for ASOS ceilometer reports in CONV reported IFR conditions.

against an instrument that records a cloud 'hit' at a very low height above ground level. The left hand population of 35 events indicates conventionally observed low ceilings with an ASOS report of no ceilings. This occurrence has no simple explanation.

IFR weather consists of a combination of weather elements. Ceiling categories are every 1,000 feet and the population is limited to conventional ceilings below 1,000 feet. It seems improbable to have comparisons of three categories (3,000 feet) lower than the conventionally observed ceiling. But the restriction causing IFR is more likely visibility related, so an observation reported conventionally as ¾ mile visibility in fog and ceiling at 5,000 feet could be reported by ASOS as ¾ mile visibility with 1,000 foot ceiling, making it a +4 category difference.

6.3 A COMPARISON OF VISIBILITY OBSERVATIONS IN IFR WEATHER

Since the visibility element is an equally common phenomena in making a weather event meet IFR criteria, it seems only logical to evaluate the 4710 visibilities available and see what trends that have been noticed in Section 5 may also appear in IFR weather. All visibility categories remain unchanged from other evaluations. Figure 6.3.1 shows the results of evaluating the data set of conventionally reported IFR weather with respect to the visibility elements.

The distribution of comparisons once again favors the idea that ASOS reports a higher visibility in low visibility conditions than does the conventional observer. In this case, the arithmetic mean would be in the neighborhood of 1.77 reportable categories higher than conventional. Bear in mind that figures 5.4.2 a and b are subsets of 6.3.1 and one can see

Visibility Scatter Diagram

cat 1	cat 2	cat 3	cat 4	cat 5	cat 6	cat 7	cat 8	cat 9	cat10	cat11	cat12	cat13	cat14	cat15	cat16	Tot
5	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9
10	8	14	4	2	0	1	0	1	1	0	0	0	0	0	0	41
7	14	76	13	6	0	5	0	2	0	0	0	0	0	0	0	123
5	7	70	27	10	1	4	2	1	1	1	0	0	0	0	0	129
4	4	42	49	27	5	10	0	3	1	1	0	0	1	0	0	147
0	0	37	41	44	8	17	0	10	2	1	0	0	0	0	0	160
1	4	26	17	41	9	35	3	19	4	1	0	0	0	0	0	160
0	1	20	25	53	7	49	7	33	9	5	0	0	0	0	0	209
0	2	18	25	49	6	60	7	69	25	10	0	0	1	0	0	272
2	0	5	10	56	13	56	8	99	47	31	0	10	2	1	0	340
2	1	6	8	44	6	50	11	84	58	47	0	17	5	0	1	340
0	0	3	7	11	2	45	1	8	58	52	0	27	7	1	0	294
0	0	4	4	14	3	22	2	79	69	110	0	48	47	13	2	417
0	0	3	2	14	2	22	0	65	51	129	0	107	141	30	4	570
0	0	5	3	5	0	11	0	21	24	60	0	70	226	149	26	600
0	1	7	2	5	2	4	0	16	9	27	0	41	173	295	317	899
36	45	337	237	381	64	391	41	582	359	475	0	320	603	489	350	4710

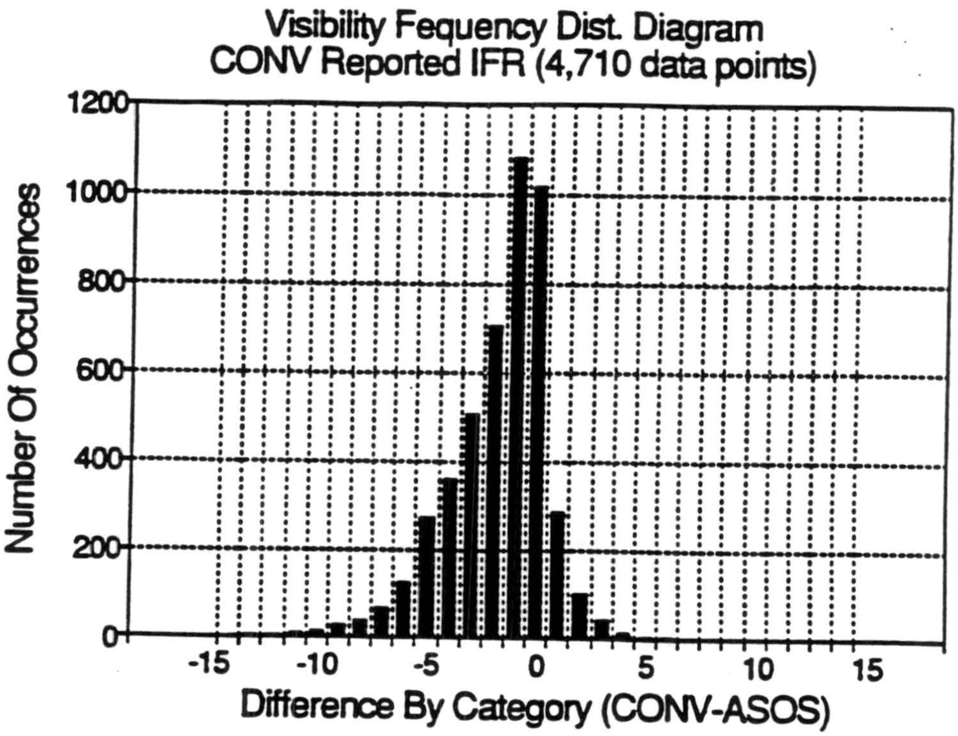


Figure 6.3.1. Scatter and frequency distribution diagram for ASOS visibility values during CONV reported IFR conditions.

that the cumulative bias stretches across all visibility ranges, culminating in the 'off center' distribution of Fig. 6.3.1.

7.0 DISCUSSION

Several other evaluations were done but not presented here because the outcomes were either non-conclusive or were supported by previous evaluations. As each evaluation was performed, a few recurring themes arose, which poses an arena for further discussion.

7.1 HUMAN NATURE OR INSTRUMENT BIAS

When noting the ASOS bias for higher visibility values than conventional values, one must ask whether the instrument is correct and the human response to low visibility is to report values that are more conservative. If this is indeed the case, then automation will be a vehicle for reporting scientific accuracy, without concern for what amounts to "reporting on safety's side". Although this is technically accurate, is it what the flying community wants. As Kraus (1993) points out in his Summary:

> "Most people who use aviation surface observations would agree that the most critical aspect to their utilization is the ability to formulate a mental picture of the situation based on the data provided. ... With the advent of automated observations the user is now being asked to develop a new understanding of the automated observation -- especially the sky condition and visibility parameters -- based upon the performance of the sensors, their location and the algorithms used to process their data."

7.2 CONVENTIONAL VISIBILITY IS MORE THAN A POINT VALUE

The scientific process of understanding a phenomena by dissection into its parts and observing each part independently works quite well with most independently functioning phenomena. This is similar to the procedure of analyzing a small sample of air and assuming it is representative of several square miles of territory. Only recently, in the young science of Ecology, has the scientific community learned to understand the behavior of phenomena through the synthesis of the phenomena with its surroundings.

7.2.1 Sector Visibility and Prevailing Visibility

The FAA and many military operations require the value of visibility in a given direction, (sector) or in a general location (prevailing). For instance, if thin low fog in the morning produces near "white out" conditions when looking "up sun" (into the rising sun) but visibility to the west (down sun) is nearly unobstructed, then aircraft need to use the direction of runway favoring the best conditions. Taking off to the west and approaching from the east, would be the logical result of this knowledge of sector visibility. However, it is only rarely that visibility controls which direction of the active runway. Usually wind direction dictates the active runway so as to take advantage of a head wind. Knowing only the objective result of aerosol scattering within a football size volume of air, gives no indication of what a pilot will encounter when viewing the horizon. Prevailing visibility is a backup value used when RVR is erroneous or not representative of the field conditions. The Authors experience with RVR meters at military installations has influenced the conclusion that prevailing visibility is a needed concept to assure smooth operations.

7.2.2 Spacial Variations

Point measurements give no indication of weather along the Flight Path for approaching and departing aircraft. Conventional observations make accommodations in the remarks of the SAO for weather phenomena not occurring at the station. These remarks represent the closeness of "services provided" with "customers needs". In the early testing of ASOS technology at Kansas City, (McNulty 1990) the implications of these remarks were considered only as they apply to forecasting, not to the non-meteorological customer who uses surface observations for a variety of decision making. For instance, a thunderstorm building off the runway with lightning in the cloud, would not be "observed" by the ASOS system, even with the inclusion of the National Lightning Network which only reports cloud to ground lightning events. An approaching aircraft, not in sight of the runway, and possibly already flying in the cloud, would only hear the computer generated voice report from ASOS and expect to "break out" at any minute. This could prove disastrous unless a trained weather observer augments the ASOS report.

Because of Public Law 100-685, ASOS will have to be augmented to provide this information, since a decrease in quality during and after modernization would be a violation of the law. However, because of the complexity of the ASOS system, augmentation of both teletype data and computer generated voice data is necessary. If augmentation, when needed, is not performed, there will be no tell-tale evidence that anything wrong has occurred, since there is no check for when augmentation is needed. (If Kraus (1993) is correct, the FAA will be replacing RVR meters with visibility meters similar to ASOS instruments, thus compounding the problem.) Spatial variations, as they represent rapidly changing or highly variable conditions, will still be a man made entry into the SAO. Just who performs this entry will be a question many people will have to ask, if indeed the era of trained NWS observers comes to an end.

7.2.3 Calibration Changes With Precipitation Type

Putting aside the variations due to spatial differences, forward scatter visibility meters depend upon the scattering geometry of the aerosol to cause a reflection that triggers a response in the receiver. Differing aerosols have different scattering cross sections and their reflectivity is different. Burnham (1993) points out that visibility sensors that are calibrated with respect to Fog show differing responses to rain and snow. In testing various visibility meters, Bradley et.al.(1991) states that the Belfort instrument used by the NWS was given a single calibration under all conditions and was the instrument of choice for the ASOS array. Only the Impulsphysik instrument had different calibrations for different weather. Bear in mind these NWS calibrations were in addition to any internal instrumentation calibration and were applied to match the instruments with transmissometers (RVR meters) not human derived visibility, for comparison. Although transmissometers do correlate well with the human eye relative to rain events, forward scatter visibility meters calibrated for fog report abnormally high extinction coefficients in rain (Burnham 1983). Either way, there is enough evidence to support the conclusion that calibration of forward scatter visibility meters is dependant upon the type of aerosol present, which implies the need for a very accurate weather indication device that can tell the visibility meter which calibration to use, based on more variables than just rain, snow, fog, or light precipitation, but also sea spray, smoke, dust, or pollution.

7.3 CLOUD HEIGHT INDICATOR CHARACTERISTICS

The subjective element of percent sky coverage for reported cloud heights from ceilometers has been removed and replaced by time averaging in ASOS. The impacts of objectivity on subjective phenomena produce results inconsistent with human needs and natural variation of a myriad of weather phenomena. The cloud height indicator is not excused from this dilemma.

7.3.1 When Blowing Phenomena is Occurring

An observer with full visual access to the celestial sky can determine the extent to which blowing particles rise into the air. In an algorithm that must be able to report cloud heights as low as 100 feet, the CHI on ASOS frequently reports these low cloud heights during events of clear sky and fog. Although this error may lie on the side of safety, for a forecaster trying to determine the extent of radiational cooling at night, it makes a significant difference. An effort is underway to determine the existence of blowing phenomena (Lewis 1993). Whether it is to be integrated with the CHI and adjustments made to cloud base or whether it is to be used solely for reporting sake is yet to be determined.

7.3.2 The Impact of Non-Reporting of Clouds Above 12,000 Feet

With the advent of ASOS in it's current configuration, gone will be the days of "twenty-five thousand thin overcast". Given the whole observation concept and after complete modernization, maybe high clouds will once again appear in the local observation. For military aircraft that refuel at levels above the capability of ASOS to determine cloud height, the lack of such knowledge may result in mission failure. Likewise the interest in global climate change will become far more confusing as the question of increased cloudiness becomes inconclusive because of inability to report the needed data after ASOS commissioning. There is an untold number of customers that use high cloud data and are unaware of the proposed changes to the observation format. Likewise, the NWS will only find out about its many varied and unknown customers when the service used becomes unavailable.

7.4 SUGGESTIONS

Aside from removing the human element from human needs, ASOS will pose a never ending opportunity for technical upgrades. Anything short of abandoning the automation of the subjective weather elements will only prolong the endeavor to search for technical solutions to non-technical problems. In the interim, two suggestions come to mind.

1. Eliminate the reportable increment in bins 1 and 2 of the CHI. Bin 1 measures the range 15 to 30 meters and Bin 2 measures 31 to 45 meters. This will allow the observational reporting of events of fog with clear sky.
2. Eliminate the point visibility measurement in favor of a rotating video camera or other full horizon device. The spatial variation of visibility is necessary for safety and should not be compromised.

8.0 CONCLUSIONS

The National Weather Service modernization program involves, among other things, a shift from manned weather observation to automated, unmanned instrument sensing. The Automated Surface Observing System (ASOS) is the device that will replace the conventional manned weather observation in use today. ASOS observations of ceiling and visibility were compared to the standard manual observations at 16 sites having at least four months of overlap data.

The 16 sites were located in the central plains states of Colorado, Nebraska, Missouri, Kansas, Oklahoma, and Texas. The period of study was confined to the precommissioning period of the sites when both conventional data and ASOS data were available. The study spans from mid September of 1991 to late July 1992, with the greatest amount of data collected between February and June 1992.

The overall results show that ASOS ceiling reports were within 1000 ft of conventional ceiling reports 92.7% of the time. Similarly, ASOS derived visibility was within one reportable category of conventionally derived visibility 93.7% of the time. These percentages were determined from a data base composed of approximately 64,000 observations.

During periods of active weather that would require a weather type entry into the coded observation, the high level of equality drops. The percentage of visibility reports within one reportable category is 60.8% and the percentage of ceilings within 1000 ft of conventional reports is 76%. These percentages were determined from a data base of approximately 9,300 observations containing a current weather entry.

There were 5,263 cases of conventionally observed weather that would be categorized as requiring IFR (Instrument Flight Rules) by the FAA (Federal Aviation Administration) for safe air travel. ASOS observations correctly identified 4,499 of these events for an 85.5% equivalency rate. ASOS observations indicated 5,129 IFR occurrences, or nearly the same amount as conventional observations.

Fog is the most frequently reported weather phenomena when large discrepancies occur between conventional and ASOS ceiling or visibility reports. This investigation shows that ASOS reported visibilities in foggy conditions are generally higher than those reported by conventional means. Ceilings in foggy conditions as reported by ASOS are generally much lower than those reported conventionally.

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