

COMPARISON OF VISIBILITY MEASUREMENTS WITH ROUTINE VISUAL OBSERVATIONS IN THE NETHERLANDS

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Abstract

Since November 2002 KNMI uses sensors in combination with algorithms to generate fully automatically the visual observations of hourly synoptic and climatological reports. KNMI uses a forward scatterometer to measure visibility. These sensors have been operated at several synoptic stations and airports throughout the Netherlands since early 2000. This paper gives a comparison of observed routine visibility reports with corresponding measurements using data of several stations for the years 2000 and 2001. The comparison generally shows good overall agreement. However, differences occur that are mainly the result of differences in location or reporting rules. This paper also focuses on fog events and investigates the effects of precipitation and darkness.

Key words: *visibility, observations, measurements, automation*

1. INTRODUCTION

The meteorological information on the present state of the atmosphere is described by routine hourly synoptic reports, so-called SYNOPs, and climatological reports (KLIMs). The observations of wind speed and direction, temperature, humidity, pressure, and precipitation amount are performed fully automatic at KNMI stations for more than a decade and hence the reports show (processed) sensor values. At some locations, an observer adds the so-called visual observations consisting of visibility, cloud amount and height and a description of the present and past weather to the report. Sensors can be used in combination with algorithms to generate automated visual observations. Since the beginning of 2000 KNMI operates cloud ceilometers and so-called present weather sensors at several stations throughout the Netherlands. In combination with a lightning detection system the sensor information is processed and used to generate fully automated reports including the visual observations. For about 2-years the automated system has been operated parallel to a manned station. The performance of the automated system was also monitored off-line at several other stations. The comparison has resulted in some improvements to the automated system. Since 2001 an existing station was upgraded to an automated visual station and in 2002 the manned station at De Bilt was automated. Since the introduction of the new measurement network of KNMI (including 2 Naval airbases) in November 2002 ALL synoptic and climatological reports are generated fully automatically. KNMI employs observers/forecasters only at airports, but they only make visual observations for aeronautical reports. In 2003 the meteorological systems of the Dutch Royal Airforce will be upgraded. This will result in a fully automated synoptic measurement network in the Netherlands.

A description of the new meteorological measurement network of the Netherlands is available elsewhere (Wauben et al., 2002). Details on the sensors and algorithms that KNMI uses for the automated visual observations can also be found in the literature (Wauben, 2001) as well as information on the performance regarding cloud and weather observations (Wauben 2002a and b). Visibility is considered in more detail in this paper.

2. VISIBILITY OBSERVATIONS

The observer performs the routine visual observations at about 5 to 10 minutes before the hour. For that purpose, he (or she) goes outside and has a look around. The visibility is defined as the maximum distance that a black object of suitable dimensions can be seen near the horizon. During daylight an observer can determine this using visibility markers at known distances. In situation with low light levels, i.e. during twilight and at night, lights are used as reference points by the observer. The reported value is the lowest visibility in any direction. The hourly synoptic values of the visibility are reported in the VV-code. The VV-code reports the visibility in steps of 100m for values up to 5km (VV=0 to 49), steps of 1000m for values between 5 and 35 km (VV=50, 56 to 80), steps of 5000m between 35 and 70km (VV=81 to 88), and all values equal to and larger than 70km are reported as VV=89. The visibility is always rounded down to the nearest VV value. The reported visibility depends on the availability of markers, the contrast between the object and the background, the intensity of the lamp and also depends on the sensitivity of the observers' eye. In practice, the observation is mostly performed from a tower or building, although the WMO regulations state that it should be performed from the observation field. At most locations the observer has access to the sensor readings of visibility.

The visibility is related to the amount of extinction of the light between object and observer. The amount of extinction, which is directly related to the so-called meteorological optical range (MOR), can be obtained by measuring the reduction of the intensity of a light beam over a known distance. Such a measurement is performed by so-called transmissometers (TMM). KNMI operates TMMs only along runways at most airports. The TMMs give accurate MOR values, but they are sensitive to contamination and their visibility range is limited. The first problem can be overcome by contamination compensation algorithms or by regular maintenance. The latter disadvantage can be solved by using several TMMs with different baselines. For synoptic purposes, and recently also for aeronautical use, KNMI employs so-called scatterometers to measure MOR. The amount of radiation scattered by a volume of air is assumed to be proportional to amount of extinction of a light caused by the same volume of air. The accuracy of scatterometers is less than that of the TMMs, but they are within the WMO and ICAO requirements. Concerning the range and the sensitivity to contamination scatterometers have better characteristics than transmissometers. KNMI uses the Vaisala FD12P Present Weather Sensor (PWS), which apart from MOR also gives precipitation type and amount. The PWS is also equipped with a background luminance unit facing North. The PWS is generally located at the synoptic observation field of the station. The PWS sampling volume is only 0.1dm³ and is at a height of about 1.5m. For synoptic purposes KNMI decided to use MOR, although MOR in combination with the background luminance and assuming a lamp of 100cd can be used to calculate the background luminance corrected visibility. The 1-minute sensor values of MOR are averaged over 10 minutes. The averaged MOR value between 10 and 0 minutes before the hour is considered the sensor value of the visibility.

3. COMPARISON FOR DE BILT 2000

In this section the observed and measured visibility at De Bilt for 2000 is discussed in detail. The observer at De Bilt is situated on the third floor of the main building of KNMI. During the visual observations the observer can go on the roof one floor above at a height of about 15m. The sensor is located at the observation field about 200m from the main KNMI building. The visibility of the observer (OBS) and sensor (PWS) is either given in the WMO code (VV)

or in meters (VIS). Unless mentioned otherwise the 10-minute averaged MOR value of the sensor from 10 minutes before to the full hour is considered the PWS value.

3.1 Example of a selected day

The observed and measured visibility values can be compared directly. The results for a selected day are shown in Fig 1. The figure shows the observed hourly visibility value in the VV-code (blue squares) and the 10-minute averaged values of the sensor (red line). A red dot indicates the 10-minute sensor value at the full hour that is compared to the observed value. Figure 1 shows an example of a day where the results are close, except for some hours during the night, where the observer missed the fog detected by the sensor. The differences are mostly the results of differences in the observing practices. An observer is located at a tower and reports the lowest visibility around. The area of the lowest visibility may not include the location of the sensor. Because of the higher position of the observer will generally have a better visibility than close to the surface. The reported values are based on visibility marks and during darkness the observation can be restricted to the regions with sufficient lighting and/or marks. The sensor is situated at a fixed location and only reports the value at that location. The sensor has no bias between day/night situations.

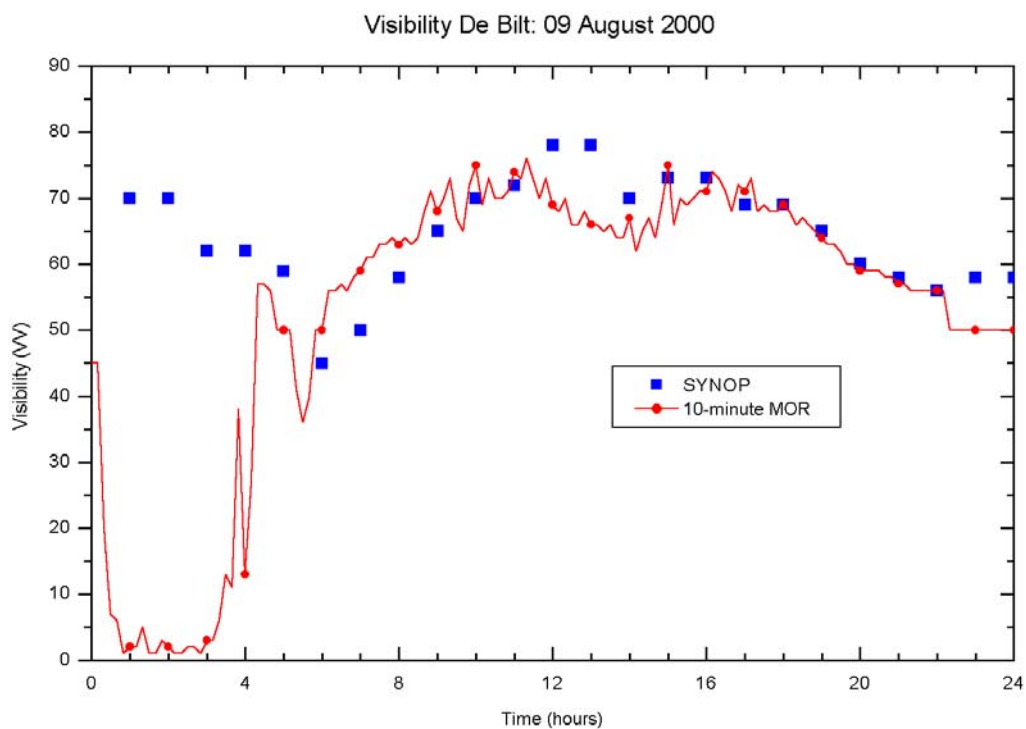


Figure 1. Comparison of observed and measured visibility for De Bilt on August 9, 2000.

A general overview of the comparison between observer and sensor can be given in various ways. Each presentation method has its own merits and the best choice depends on the purpose. The presentations considered in this paper are given in the following sub-sections. In all cases the comparison is restricted to the cases that both observed and measured visibility are available. The sensor values are sometimes missing because of problems with the acquisition of the results or periods when the sensor was not in use.

3.2 VV contingency matrix

The visibility values in VV-code can be grouped in order to get a reasonable size of a contingency matrix. Such a table is given for De Bilt 2000 in Table 1. The table gives the number of hours with observed and sensor values in the indicated range. Note that the indicated range is the upper visibility boundary of the bin, the lower boundary is the given by the entry above (to the left). The selected boundaries 100m, 200m, 500m, 1km, 2km, 5km, 10km and 20km form more or less a logarithmic scale. Table 1 shows that most entries are near the diagonal of the matrix. However, situations do occur where observer and sensor visibility give considerable differences. Situations where the sensor reports much lower values than the observer occur more often than vice versa. The reason for the differences has been mentioned above. In fact, the situation on 9 August 2000 accounts for 3 of the 5 entries with observed value between 10-20km and sensor value between 200 and 500m. A general measure of the agreement between observer and sensor visibility can be given by the fraction of entries where both agree, i.e. the fraction of entries on the diagonal. In Table 1 the percentage of events on the diagonal (DIAG) is 67%. However, this number strongly depends on the choice of the visibility ranges. Also, 2 values close to one another, but just at opposite sides of a boundary would be counted as wrong. Calculating the average difference between the observed and sensor in the original VV-code table gives a better measure of the quality. In that calculation the non-existence of VV-codes 51 to 55 is taken into account. The averaged value of the differences (VVobs-VVpws) is 3.5, i.e. the observer on average gives a VV-value that is about 3 VV-units higher. The averaged value of the absolute values of the differences $\text{abs}(\text{VVobs}-\text{VVpws})$ is 5.4 and indicates the average difference in the original VV table with 90 bins.

Table 1. Measured versus observed visibility contingency matrix for De Bilt 2000.

OBS	Visibility at De Bilt in 2000, PWS										
	NA	<100m	<200m	<500m	<1km	<2km	<5km	<10km	<20km	≥20km	all
NA	0	0	0	0	0	0	0	0	0	0	0
<100m	0	4	4	1	0	0	0	0	0	0	9
<200m	1	1	13	5	0	1	0	0	0	0	21
<500m	1	0	7	19	16	5	0	0	0	0	48
<1km	1	0	8	9	26	12	3	0	0	0	59
<2km	3	0	2	7	15	119	32	1	0	0	179
<5km	42	1	9	19	25	111	711	127	8	1	1054
<10km	45	0	3	7	8	27	295	1098	140	5	1628
<20km	39	0	3	3	15	14	84	622	1425	178	2383
≥20km	83	0	0	8	3	6	24	105	1012	2162	3403
all	215	6	49	78	108	295	1149	1953	2585	2346	8784

3.3 Distribution of visibility ratio

The differences between the observed and measured visibility can also be studied by considering their ratio $\text{VISpws}/\text{VISobs}$. By considering the ratio, the effect of the varying VV bin size is eliminated. Figure 2 gives the frequency distribution of the relative differences. The vertical axis shows the number of events in a relative difference bin. The horizontal axis shows the relative difference bins. Note that the relative difference is plotted as $200 \cdot \log(\text{VISpws}/\text{VISobs})$ to get a more or less symmetric shape of the differences around zero and a good view of the details. In order to get an indication of the corresponding relative differences the position of some specific ratios is given at the top of the figure. The bins -101

and 101 contain the entries with differences outside the range. The frequency distribution has more or less a symmetric shape around zero. However, large negative values occur more often than positive value. Also note the 271 entries at -101 compared to 21 entries at 101. The results of this figure can be summarised by a mean difference of the ratio VIS_{pws}/VIS_{obs} of 0.97 with a standard deviation of 0.38. Since the distribution is not exactly Gaussian the summary can better be given as a median of 0.93 and 90% level between 0.41 and 1.62 (thus 5% of the events are below a ratio of 0.41 and 5% above 1.62). The 95% levels are at ratios 0.31 and 1.86. The mean and median and their widths are given by the vertical and horizontal lines in Fig. 2.

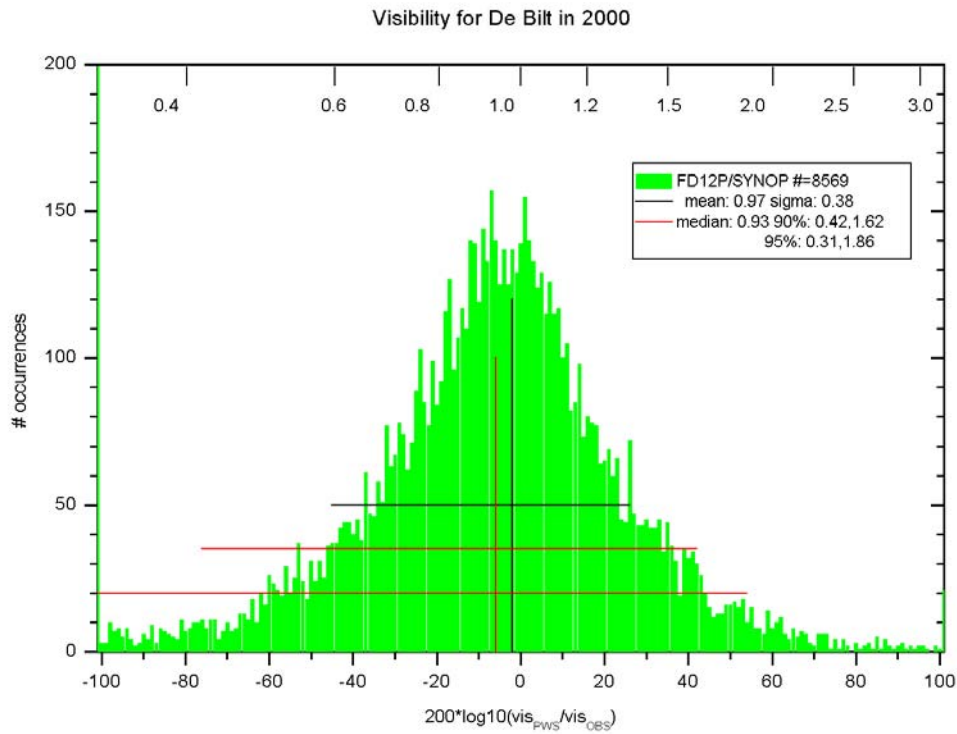


Figure 2. *Distribution of measured versus observed visibility ratio for De Bilt 2000.*

3.4 Box plot

A scatter plot does not give an elegant overview due to the large number of VV bins. Therefore, the VV bins are grouped like in the contingency matrix and the results are presented in a so-called box plot (see Fig. 3). The box plot shows the position of several parameters for the ratio PWS/OBS in each interval in a logarithmic scale. The results for the different observed visibility intervals are plotted at the corresponding $\log(\text{VIS})$ level of the upper boundary. Since the statistics below 500m is rather poor these bins are combined in one. The lowest entry shows the parameters for the full visibility range. The upper boundaries and number of entries in each visibility range are indicated on the right hand side of the figure. For each interval the box plot shows (if within the ratio range): the minimum ratio (denoted by “>”); the range containing 99% of the entries (first and second “|” denote ratio with 0.5% of the entries below and above, respectively); the range containing 90% of the entries (denoted by “-”); the range containing 50% of the entries (denoted by “□”); and the median value (denoted by “X”).

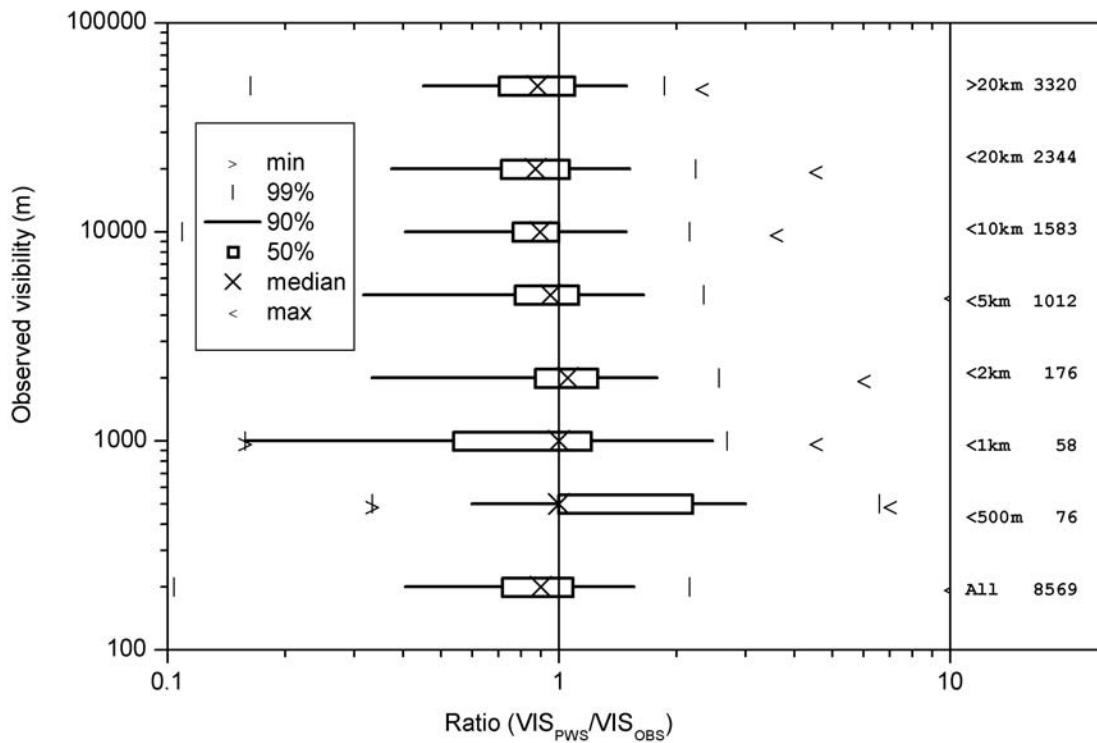


Figure 3. Box plot of measured versus observed visibility ratio for De Bilt 2000.

3.5 Fog contingency matrix

The comparison of a specific event, such as the report of fog ($VIS < 1\text{km}$), between observer and sensor can be given by a 2-by-2 contingency matrix denoted by the yellow squares in Table 1. The 4 regions of the table are (H) a hit if OBS and PWS agree that fog is present, (N) no fog reported by OBS and PWS, (M) a miss if OBS gives fog but PWS not, and (F) a fault when OBS gives no fog but PWS does. These regions are given in Table 2. The agreement can then be expressed in scores defined in Table 2. The fog cases of De Bilt 2000 have a probability of detection (POD) of 78.8%, the false alarm rate (FAR) is 50.6%, and the critical success index (CSI) is 43.6%. The rather poor score of fog is mainly a result of the differences in observing practices. An observer reports fog if the visibility is below 1km anywhere in the surroundings, the sensor only report fog if the 10-minute averaged value is below the limit. On the other hand the observer does not report fog close to the ground. The bias in the fog contingency matrix is 1.60 and the correlation coefficient is 0.62.

Table 2. Measured versus observed fog contingency matrix.

2-by-2 contingency matrix			
	Event	PWS	
		yes	no
OBS	yes	H	M
	no	F	N

Scores	Probability Of Detection (POD) = $100 \cdot H / (H + M)$
	Fals Alarm Rate (FAR) = $100 \cdot F / (F + H)$
	Critical Succes Index (CSI) = $100 \cdot H / (H + M + F)$
	Bias = $(H + F) / (H + M)$
	Correlation coefficient (CC) = $(HN - MF) / \sqrt{[(H + M)(H + F)(N + M)(N + F)]}$

3.6 Overview and performance under specific situations

Table 3 shows an overview of the results of the various comparison between measured and observed visibility discussed in the previous sections for De Bilt 2000. The previous results are summarised in the column marked MOR. The column Vis gives the scores for the background luminance corrected MOR. The difference between MOR and Vis is generally very small except in situations with a low MOR and low background luminance. In those situations Vis is larger than MOR. Table 3 shows that the overall performance of MOR and Vis is nearly the same, but the number of fog cases reported is 10% less for Vis. The 10% reduction is equally distributed between correctly and falsely reported fog events. The bias between measured and observed fog cases is less for Vis compared to MOR.

Table 3 also shows the performance of measured MOR versus observed visibility for day and night situations separately. Daytime cases are defined as situations where the background luminance measured by the PWS is above 10cd/m². During daytime the overall agreement is much better than at night. The detection of fog is better at night than during daytime, but at the expense of a large increase in false alarms. The CSI and the bias for fog detection are better during daytime than at night. The ratio of measured and observed visibility is generally less than one, meaning that the PWS reports on average smaller values. During daytime this ratio is closer to unity.

Finally, Table 3 contains in the last 2 columns the scores for dry and wet events. The precipitation events, denoted by wet, are the cases where the precipitation intensity reported by the PWS is larger than 0mm/h. Table 3 shows that in dry situations the PWS in general reports lower visibilities than the observer, whereas in wet cases the PWS reports higher visibilities. In case of precipitation the PWS subtracts the precipitation signal from the scattered signal. The effect of precipitation on extinction and scattering is different and furthermore depends on the type and size distribution of the precipitation particles. The correction to be applied by the PWS is therefore not straightforward.

Table 3. Overview of performance of measured versus observed visibility for De Bilt 2000.

<i>Parameter</i>	<i>MOR</i>	<i>Vis</i>	<i>Day</i>	<i>Night</i>	<i>Dry</i>	<i>Wet</i>
<i>Total # cases</i>	8569	8569	4606	3963	7155	1414
<i>DIAG</i>	65%	65%	71%	58%	65%	65%
<i>(VVobs-VVpws)</i>	3.5	3.2	1.4	5.8	3.9	1.2
<i>abs(VVobs-VVpws)</i>	5.4	5.3	4.4	6.6	5.5	5.0
<i>Mean/Std ratio</i>	0.94/0.40	0.95/0.45	1.01/0.42	0.85/0.38	0.91/0.37	1.06/0.53
<i>Median ratio</i>	0.90	0.91	0.95	0.84	0.88	1.00
<i>50% ratio</i>	0.72/1.09	0.73/1.11	0.78/1.15	0.64/1.00	0.71/1.07	0.78/1.20
<i>90% ratio</i>	0.41/1.56	0.42/1.58	0.56/1.67	0.27/1.46	0.37/1.49	0.52/1.83
<i>Number fog hits</i>	113	96	43	70	107	6
<i>POD fog</i>	84.3%	71.6%	72.9%	93.3%	87.7%	50.0%
<i>FAR fog</i>	53.1%	45.5%	31.7%	60.7%	53.1%	53.8%
<i>CSI fog</i>	43.1%	44.9%	54.4%	38.3%	44.0%	31.6%
<i>BIAS fog</i>	1.80	1.31	1.07	2.37	1.87	1.08
<i>CC fog</i>	0.62	0.62	0.70	0.60	0.63	0.48

4. COMPARISON FOR OTHER STATIONS

4.1 Results for Amsterdam Airport Schiphol 2000

In this section the results for observed and measured visibility at Amsterdam Airport Schiphol for 2000 are given. Schiphol is a 5-runway airport where the observer is situated in a tower at an altitude of about 40m and the observation field is located at a distance of about

4km. Furthermore, the observer has access to 15 TMM readings situated along the runways in an area with a radius of about 5km around the observer.

Table 4. Measured versus observed visibility contingency matrix for Schiphol in 2000.

OBS	Visibility at Schiphol in 2000, PWS										
	NA	<100m	<200m	<500m	<1km	<2km	<5km	<10km	<20km	≥20km	all
NA	0	0	0	0	0	0	0	0	0	0	0
<100m	0	0	0	0	0	0	0	0	0	0	0
<200m	0	0	0	0	0	0	0	0	0	0	0
<500m	0	9	22	11	0	0	0	0	0	0	42
<1km	0	0	3	27	10	1	0	0	0	0	41
<2km	0	0	0	4	29	43	8	0	0	0	84
<5km	2	0	4	3	2	109	590	41	8	2	761
<10km	10	0	4	1	2	6	420	1203	119	26	1791
<20km	7	0	3	2	0	2	28	881	1532	160	2615
≥20km	5	0	0	1	0	1	8	45	1378	2012	3450
all	24	9	36	49	43	162	1054	2170	3037	2200	8784

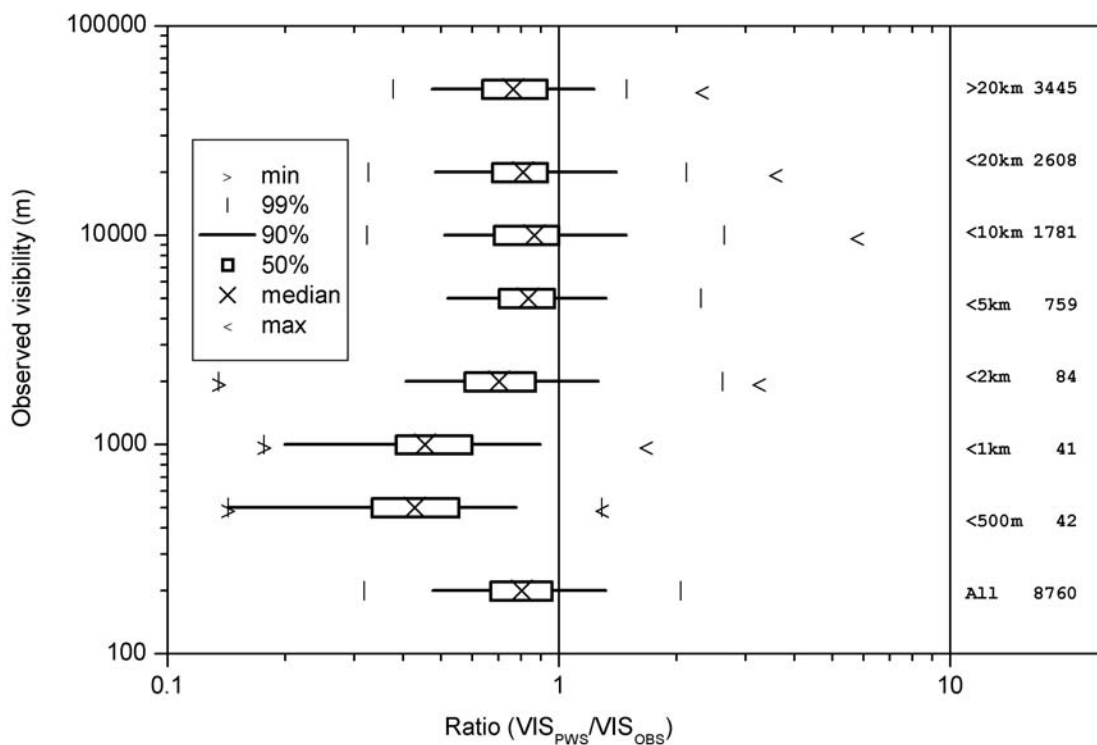


Figure 4. Box plot of measured versus observed visibility ratio for Schiphol 2000.

The visibility contingency matrix and the box plot for Schiphol 2000 are given in Table 4 and Fig. 4, respectively. Compared to the results for De Bilt, the PWS visibilities are even lower compared to the observed values. This is particularly the case for visibility values for below 2km. The deviation around 1km visibility, which is characteristic for all airports compared to other stations, disappears if the box-plot is made using background luminance corrected visibility of the PWS. The reason is probably twofold. First, the illumination levels

at airports during night will generally be higher compared to other stations. Secondly, for airport practices the background illumination corrected visibility is used whereas for synoptical purposes MOR is prescribed. This difference is also reflected on the presentation screens. Moreover, the availability/use of TMM readings at airports, especially for the low visibility range, might play a role.

An overview of the performance for Schiphol 2000 is given in Table 5. It shows the same behaviour when a distinction between day/night and dry/precipitation situations is made as for De Bilt. A noticeable difference between De Bilt and Schiphol are the scores for fog events. These are generally better for Schiphol compared to the scores for De Bilt (cf. Table 3).

Table 5. Overview of performance of measured versus observed visibility for Schiphol 2000.

Parameter	MOR	Vis	Day	Night	Dry	Wet
Total # cases	8760	8760	4730	4030	7380	1380
DIAG	62%	63%	69%	53%	61%	67%
(VVobs-VVpws)	4.4	4.2	3.0	6.1	4.8	2.1
abs(VVobs-VVpws)	5.0	4.9	4.3	5.9	5.2	4.3
Mean/Std ratio	0.84/0.34	0.85/0.34	0.89/0.37	0.78/0.30	0.81/0.31	1.00/0.45
Median ratio	0.80	0.81	0.84	0.75	0.78	0.91
50% ratio	0.67/0.96	0.68/0.97	0.71/1.00	0.61/0.91	0.65/0.93	0.77/1.11
90% ratio	0.48/1.32	0.49/1.32	0.55/1.39	0.43/1.24	0.47/1.23	0.56/1.77
Number fog hits	82	80	30	52	78	4
POD fog	98.8%	96.4%	100.0%	98.1%	98.7%	100.0%
FAR fog	40.1%	27.3%	28.6%	45.3%	39.5%	50.0%
CSI fog	59.4%	70.8%	71.4%	54.2%	60.0%	50.0%
BIAS fog	1.65	1.33	1.40	1.79	1.63	2.00
CC fog	0.77	0.84	0.84	0.73	0.77	0.71

4.2 Results for other stations in 2000 and 2001

Table 6. Overview of visibility performance for several stations in the Netherlands in 2000.

Parameter	De Bilt	Schiphol	Rotterdam	Eelde	Beek	De Kooij*	Vlissingen**
Total # cases	8569	8760	8185	7989	7987	5641	2173
DIAG	65%	62%	64%	80%	80%	68%	42%
(VVobs-VVpws)	3.5	4.4	3.3	1.4	1.9	1.2	6.0
abs(VVobs-VVpws)	5.4	5.0	4.5	2.9	2.6	4.7	6.6
Mean/Std ratio	0.94/0.41	0.84/0.34	0.89/0.38	0.96/0.35	0.92/0.20	1.03/0.43	0.77/0.40
Median ratio	0.90	0.80	0.87	0.95	0.93	1.00	0.69
50% ratio	0.72/1.09	0.67/0.96	0.71/1.00	0.83/1.00	0.81/1.00	0.78/1.19	0.56/0.88
90% ratio	0.41/1.56	0.48/1.32	0.46/1.39	0.60/1.32	0.62/1.20	0.53/1.77	0.42/1.32
Number fog hits	113	82	163	148	59	42	18
POD fog	84.3%	98.8%	95.9%	91.4%	90.9%	100%	94.7%
FAR fog	53.1%	40.1%	34.0%	31.8%	41.2%	44.7%	5.3%
CSI fog	43.1%	59.4%	64.2%	64.1%	55.6%	55.3%	90.0%
BIAS fog	1.80	1.65	1.45	1.34	1.55	1.81	1.00
CC fog	0.62	0.77	0.79	0.78	0.73	0.74	0.95

* PWS De Kooij was installed in May 2000. ** PWS Vlissingen was installed in September 2000.

The overview of the performance for several stations throughout the Netherlands are given in Tables 6 and 7 for the years 2000 and 2001, respectively. De Bilt is the central location of KNMI in the centre of the Netherlands; Schipol is a large airport and Rotterdam a regional airport both in the Western part of the Netherlands; Eelde and Beek are regional airports in respectively the SE and NE; Vlissingen and the naval airbase De Kooij are coastal stations in respectively the SW and NW of the Netherlands. The overview shows: the regional airports

Eelde and Beek have the narrowest distributions; the airports show the best agreement for fog detection; De Kooij, an airbase with one PWS and no TMM, more resembles the synoptic stations; De Kooij is the only station where the PWS reports on average larger visibility values than the observer.

Table 7. Overview of visibility performance for several stations in the Netherlands in 2001.

<i>Parameter</i>	<i>De Bilt</i>	<i>Schiphol</i>	<i>Rotterdam</i>	<i>Eelde</i>	<i>Beek</i>	<i>De Kooij</i>	<i>Vlissingen</i>
<i>Total number</i>	8671	8745	8626	8714	8717	8731	8727
<i>DIAG</i>	68%	61%	60%	79%	81%	67%	54%
<i>(VVobs-VVpws)</i>	2.8	4.3	4.7	1.2	1.6	0.9	4.1
<i>abs(VVobs-VVpws)</i>	5.1	5.4	5.6	3.1	2.6	4.8	5.8
<i>Mean/Std ratio</i>	0.98/0.45	0.86/0.43	0.85/0.36	0.97/0.34	0.94/0.22	1.06/0.57	0.88/0.48
<i>Median ratio</i>	0.93	0.78	0.83	0.96	0.93	1.00	0.81
<i>50% ratio</i>	0.76/1.12	0.65/0.97	0.65/1.00	0.83/1.04	0.84/1.00	0.77/1.19	0.61/1.00
<i>90% ratio</i>	0.41/1.59	0.47/1.40	0.41/1.40	0.57/1.39	0.62/1.24	0.53/1.86	0.41/1.52
<i>Number fog hits</i>	204	117	151	296	194	195	107
<i>POD fog</i>	81.6%	92.1%	96.2%	95.2%	98.0%	87.1%	85.6%
<i>FAR fog</i>	34.0%	32.8%	49.0%	28.0%	26.2%	22.9%	13.7%
<i>CSI fog</i>	57.5%	63.6%	50.0%	69.5%	72.7%	69.1%	75.4%
<i>BIAS fog</i>	1.24	1.37	1.89	1.32	1.33	1.13	0.99
<i>CC fog</i>	0.73	0.78	0.69	0.82	0.85	0.81	0.86

5. CONCLUSIONS

Measured and observed MOR values generally show good overall agreement. However, differences occur that are mainly the result of differences in location (sensor at typically measures at a height of 1.5m and the observer at 15m) or reporting rules (sensor reports 10-minute averaged value, an observer the lowest observed value around). The results for 2000 and 2001 are generally the same, but show some differences that are the result of different weather conditions between 2000 and 2001. The differences between the stations are the result of local conditions, the set-up, and practises. Table 8 shows the results for Lelystad Airport where 2 PWS' are located along the runway. The results give an indication of the differences that occur for 2 identical sensors separated by about 1km. It should be noted that in addition to

the hourly reports, KNMI also provides every 10minutes sensor data of all stations to the users.

Table 8. Overview for 2 PWS sensors at Lelystad 2001.

<i>Parameter</i>	<i>PWS 1 vs. 2</i>
<i>Total # cases</i>	8083
<i>DIAG</i>	89%
<i>(VVobs-VVpws)</i>	-0.4
<i>abs(VVobs-VVpws)</i>	1.7
<i>Mean/Std ratio</i>	1.05/0.49
<i>Median ratio</i>	1.00
<i>50% ratio</i>	0.96/1.11
<i>90% ratio</i>	0.81/1.29
<i>Number fog hits</i>	301
<i>POD fog</i>	89.1%
<i>FAR fog</i>	3.8%
<i>CSI fog</i>	86.0%
<i>BIAS fog</i>	0.93
<i>CC fog</i>	0.92

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