UNIVERSITÄT BAYREUTH

Abt. Mikrometeorologie

Comparison of the sonic anemometer Young Model 81000 during VOITEX-99

Thomas Foken

Arbeitsergebnisse

Nr. 08

Bayreuth, Oktober 1999

Erratum

Correction by R. M. Young Company, 26 Oct. 1999

... We have identified an 8.06 % scaling error which will affect the output from the Model 81000 at all velocities. The output will be perfectly linear, however all values reported will be low by 8.06 %. .....

The data of this report are **not** corrected.

Correction of Table 1 (bold)

	experiment	etalon	device	coeff.	abs. value	R^2
v_h	LINEX-96/2	DAT-310/A	DAT-310/A	1.03	0.04 m/s	0.99
			CSAT3	0.99	-0.14 m/s	0.95
			Solent	1.03	0.03 m/s	0.99
	VOITEX-99	CSAT3	Young	0.98	-0.0**6** m/s	0.98
σ_{vh}	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.004 m/s	0.98
			CSAT3	1.03	-0.02 m/s	0.98
			Solent	1.02	-0.01 m/s	0.96
	VOITEX-99	CSAT3	Young	0.95	**-** 0.01 m/s	0.95
σ_w	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.01 m/s	1.00
			CSAT3	0.99	0.02 m/s	0.99
	VOITEX-99	CSAT3	Young	0.82	**-** 0.01 m/s	0.98

Correction of Table 2 (bold)

	experiment	etalon	device	coeff.	abs. value	R^2
T_a	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.58 K	1.00
			CSAT3	1.07	-1.52 K	0.99
	VOITEX-99	CSAT3	Young	0.95	-0.**50** K	1.00
σ_{Ta}	LINEX-96/2	DAT-310/A	DAT-310/A	0.98	0.01 K	0.98
			CSAT3	0.99	-0.04 K	0.97
	VOITEX-99	CSAT3	Young	0.98	0.00 K	0.94

Correction of Table 3 (bold)

	experiment	etalon	device	coeff.	abs. value	R^2
$\overline{w'v_h'}$	LINEX-96/2	DAT-310/A	DAT-310/A	1.07	-0.00 (m/s)2	0.96
			CSAT3	1.22	0.02 (m/s)2	0.94
	VOITEX-99	CSAT3	Young	0.**86**	0.00 (m/s)2	0.82
$\overline{w'T_a'}$	LINEX-96/2	DAT-310/A	DAT-310/A	1.07	0.002 m·K/s	0.97
			CSAT3	0.98	-0.001 m·K/s	0.97
	VOITEX-99	CSAT3	Young	0.**81**	0.003 m·K/s	0.96

Correction of the reference Foken et al. (1999):

Foken, Th., Wichura, B., Gerchau, J., Göckede, M., Mertens, M., Subke, J.-A., 2000: Dokumentation des Experimentes VOITEX-99, 28.06.1999 bis 30.07.1999. Universität Bayreuth, Abt. Mikrometeorologie, Arbeitsergebnisse, Nr. 12, 25 S.

Comparison of the sonic anemometer Young Model 81000 during VOITEX-99

1. Introduction

The paper presents a comparison of the new sonic anemometer produced by YOUNG (Young, 1999) with the reference sonic anemometer CSAT3 during the VOITEX-99 experiment. The comparison was supported by GWU and Young.

The experiment VOITEX-99 was not designed as a comparison experiment. The basic aim of the experiment was study the interaction of the land surface and the atmosphere. However, several measuring systems and devices were tested during this experiment. The experiment took place in the upper Eger basin near the small town of Weissenstadt in the Fichtelgebirge mountains (Germany, North Eastern part of Bavaria). The documentation of the experiment is given by Foken et al. (1999).

The measuring place was a flat meadow with a canopy height of about 0.2 m. With a good fetch of 150 to 250 m, good footprint conditions were realised. Only the data of July 15, 21 and 22 with ideal wind directions were used for the comparison. The measuring height for both instruments was 2.5 m. The installation is shown in Fig. 1.

As the etalon the sonic anemometer CSAT3 by Campbell Sci., well orientated into the mean wind direction, was used with a sampling frequency of 20 Hz. The prototype of the Young sonic anemometer had no time information, therefore, a special terminal programme must be used with a sampling frequency of 5 Hz. The data processing was done without any correction and rotation of the co-ordinate system. The quality of the data was checked according to Foken and Wichura (1996) and only single measurements in the night were selected.

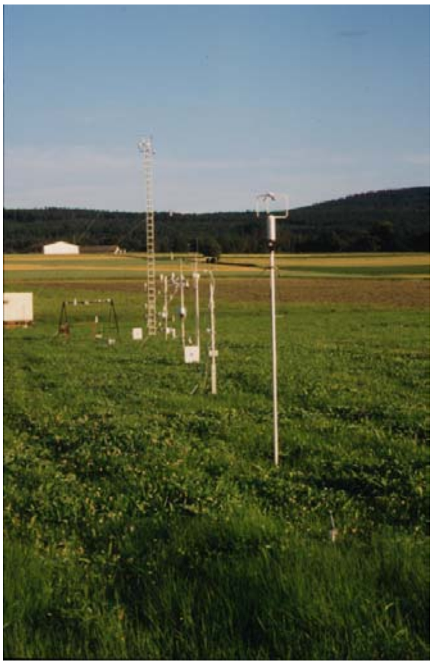

Fig. 1: Sonic anemometers during the VOITEX-99 experiment: In the foreground Young No. 81000 followed by Gill Instruments 'Solent R2', two METEK 'USA-1' and 'CSAT3'.

2. Results of the comparison

For comparison of the results found by the Young sonic anemometer with typical results of other anemometers the data presented by Foken et al. (1997) are included in the given tables. For these experiments the Kaijo-Denki DAT 310/A was used as a etalon.

2.1 Wind parameters

The results for mean horizontal wind speed (Fig. 2) and its standard deviation (Fig. 3) are excellent in the range of dispersions for atmospheric comparison experiments (Table 3). Similar results were also found by Foken et al (1994) and Foken and Weisensee (1998).

The standard deviation of the vertical wind velocity (Fig. 4) is normal for the investigated type of a sonic anemometer with a significant reduction of the standard deviation due to the fixing of the anemometer. Because of the low sampling rate of 5 Hz, the comparison result with a high sampling rate of 20 Hz would be normally about 5 percent better.

Table 1: Comparison of averaged wind parameters (30min), with etalons during LINEX-96/2 (Foken et al., 1997) and the Young sonic anemometer during VOITEX-99

	experiment	etalon	device	coeff.	abs. value	R^2
v_h	LINEX-96/2	DAT-310/A	DAT-310/A	1.03	0.04 m/s	0.99
			CSAT3	0.99	-0.14 m/s	0.95
			Solent	1.03	0.03 m/s	0.99
	VOITEX-99	CSAT3	Young	0.98	-0.05 m/s	0.98
σ_{vh}	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.004 m/s	0.98
			CSAT3	1.03	-0.02 m/s	0.98
			Solent	1.02	-0.01 m/s	0.96
	VOITEX-99	CSAT3	Young	0.95	0.01 m/s	0.95
σ_w	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.01 m/s	1.00
			CSAT3	0.99	0.02 m/s	0.99
	VOITEX-99	CSAT3	Young	0.82	0.01 m/s	0.98

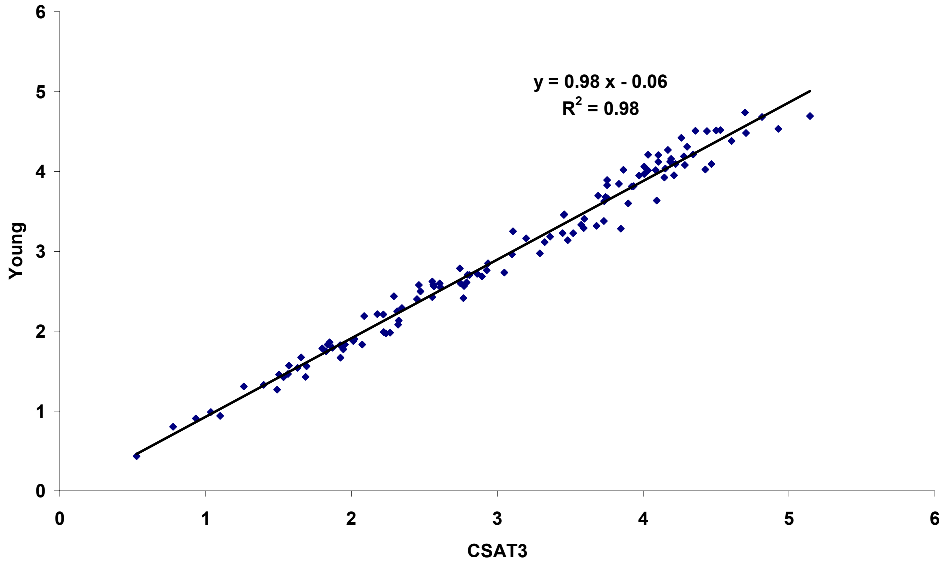

Fig. 2: Comparison of the mean horizontal wind velocity in m/s.

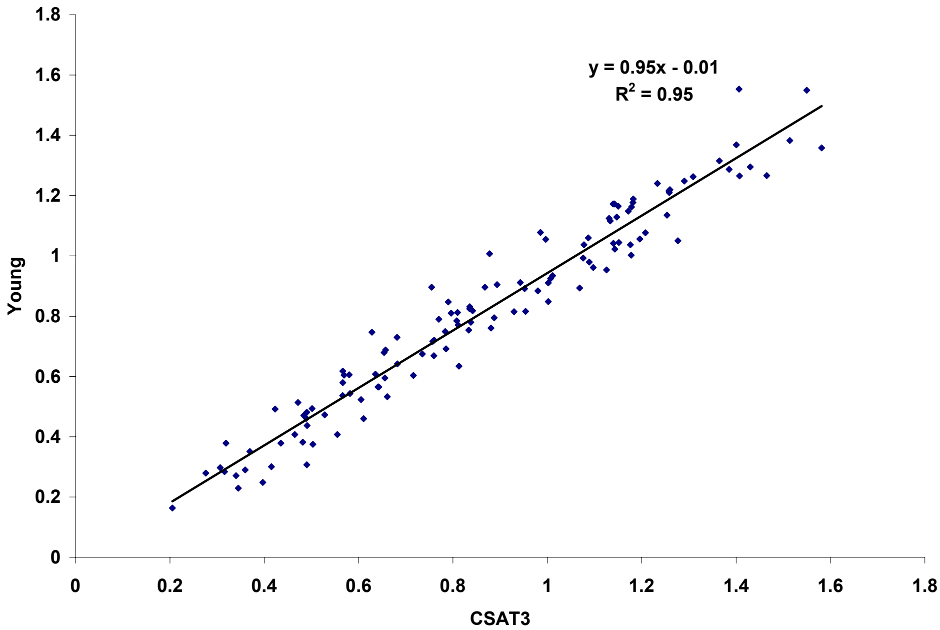

Fig. 3: Comparison of the standard deviation of the horizontal wind velocity in m/s.

If the mean vertical wind velocity was below 0.05 m/s, the differences are caused by inexact orientation and not by special sensor problems. The mean values are (0.0154 ± 0.0157) m/s for CSAT 3 (N=140) and (-0.0222 ± 0.0167) m/s for Young (N=125). The found problems of the vertical wind component of the Young sensor were found only for the dispersion.

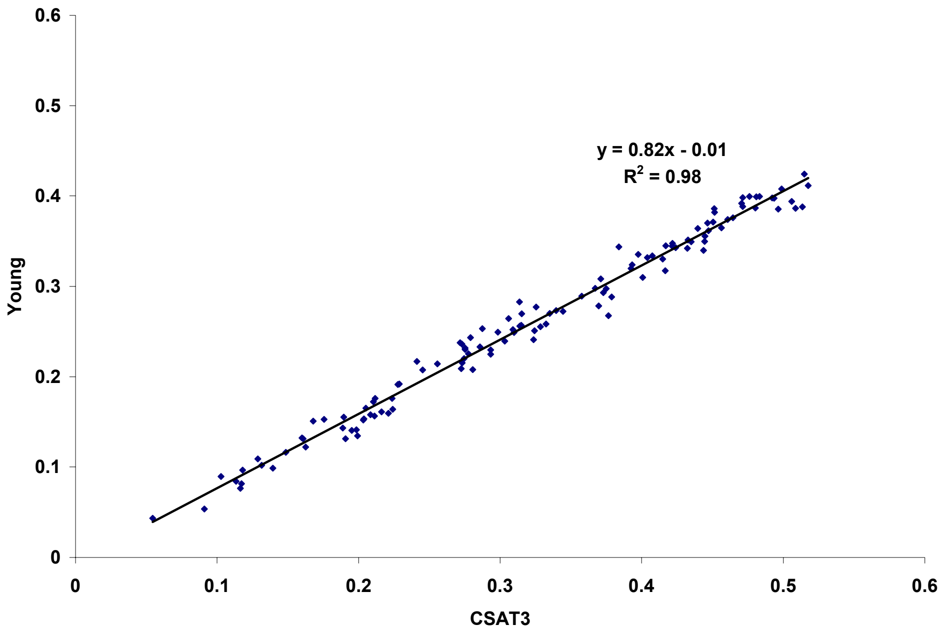

Fig. 4: Comparison standard deviation of the vertical wind velocity in m/s.

2.2 Temperature parameters

The comparison of the sonic temperature is for most of the sonic anemometers excellent. The underestimation of the mean temperature by the Young anemometer may be caused by an overestimation of the CSAT3 etalon.

Table 2: Comparison of averaged temperature parameters (30min), with etalons during LINEX-96/2 (Foken et al., 1997) and the Young sonic anemometer during VOITEX-99

	experiment	etalon	device	coeff.	abs. value	R^2
T_a	LINEX-96/2	DAT-310/A	DAT-310/A	1.00	0.58 K	1.00
			CSAT3	1.07	-1.52 K	0.99
	VOITEX-99	CSAT3	Young	0.95	-0.05 K	1.00
σ_{Ta}	LINEX-96/2	DAT-310/A	DAT-310/A	0.98	0.01 K	0.98
			CSAT3	0.99	-0.04 K	0.97
	VOITEX-99	CSAT3	Young	0.98	0.00 K	0.94

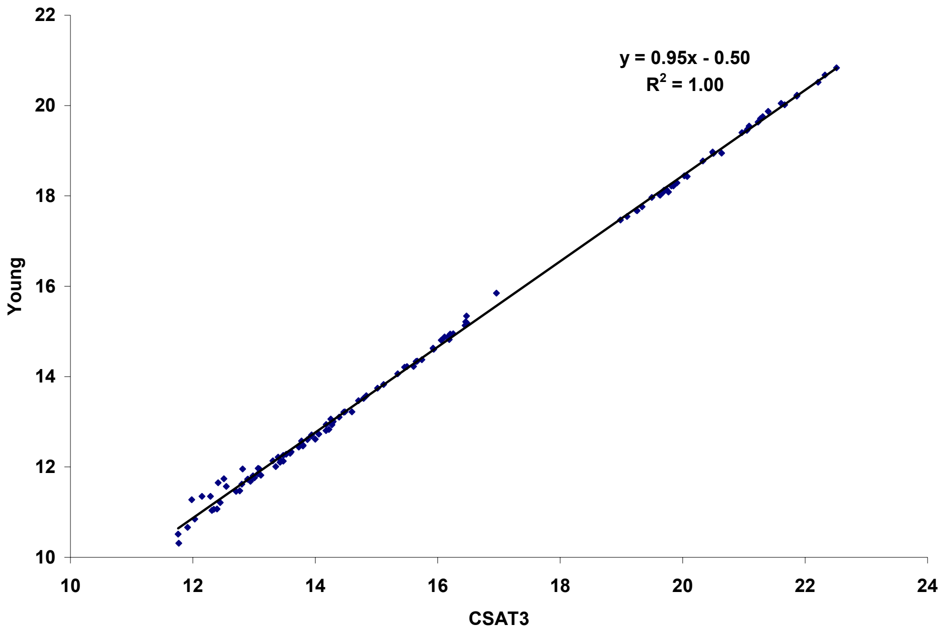

Fig. 5: Comparison the mean sonic temperature in °C.

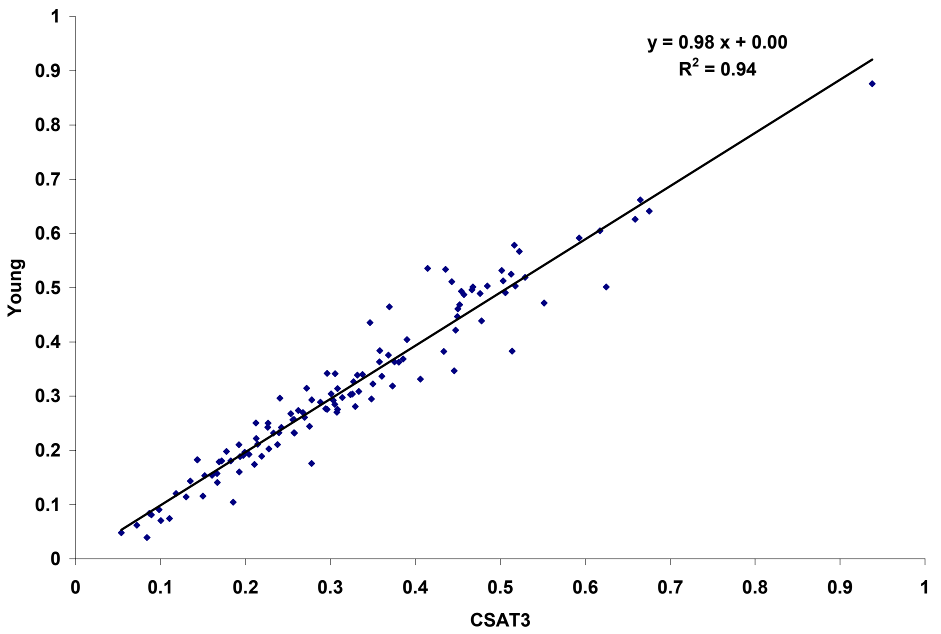

Fig. 6: Comparison standard deviation of sonic temperature in K.

It should be noted that the sonic temperature is equal with a very small error to the virtual temperature. Therefore, the standard deviation is about 10-20 % higher in comparison to the temperature depending on the humidity of the air.

2.3 Turbulent fluxes

The significant reduction of the turbulent fluxes (Fig. 7 and 8) is caused by the reduced vertical wind velocity. This result is typical for sonic anemometers with a large fixing below the measuring volume of the vertical wind velocity. Because of the low sampling rate of 5 Hz, comparison with a high sampling rate would normally be better, but with a reduction of the flux. If the overestimation of the momentum flux, which was found by Foken et al. (1997) for CSAT3 is typical, the comparison result for the momentum flux may be better as found (Table 3). Bear in mind that the anemometer measures the buoyancy flux and not the sensible heat flux, which is about 10 to 20 percent lower depending on the humidity.

Table 3: Comparison of averaged momentum and buoyancy fluxes (30min), with etalons during LINEX-96/2 (Foken et al., 1997) and the Young sonic anemometer during VOITEX-99

	experiment	etalon	device	coeff.	abs. value	R^2
$\overline{w'v_h'}$	LINEX-96/2	DAT-310/A	DAT-310/A	1.07	-0.00 (m/s)2	0.96
			CSAT3	1.22	0.02 (m/s)2	0.94
	VOITEX-99	CSAT3	Young	0.95	0.00 (m/s)2	0.82
$\overline{w'T_a'}$	LINEX-96/2	DAT-310/A	DAT-310/A	1.07	0.002 m·K/s	0.97
			CSAT3	0.98	-0.001 m·K/s	0.97
	VOITEX-99	CSAT3	Young	0.98	0.003 m·K/s	0.96

3. Conclusions

The sonic anemometer by Young is a low cost anemometer with good and stable characteristics of the mean wind parameters. The same result can be considered for the sonic temperatures. All dispersions are in the range of the normal scattering of different sonic anemometers (Foken et al., 1994, 1997) and even the often used etalon Kaijo-Denki DAT 310/A (Hanafusa et al., 1982) shows between the same anemometer type differences of the same order (Foken and Weisensee, 1998).

A problem was found in the reduction of the standard deviation of the vertical wind velocity due to the large fixing below the measuring volume. The effect may be smaller than found, if the sensor and the etalon can be compared with the same sampling frequency. Therefore, the output signal must include time information.

Due to this effect reduced momentum and buoyancy fluxes were also found. The anemometer can be used for standard flux measurements with a correction of this effect. For the determination of the correction function further comparisons are necessary using equivalent sampling rates.

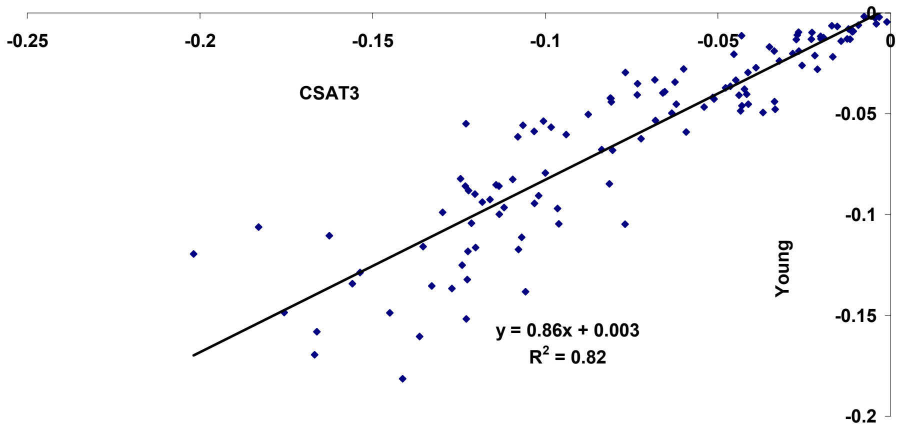

Fig. 7: Comparison of the momentum flux in $(m/s)^2$

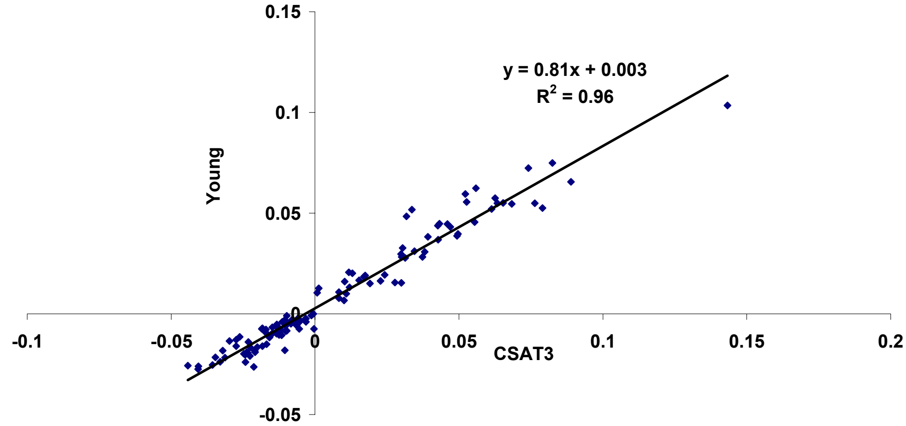

Fig. 8: Comparison of the buoyancy flux in K·m/s

4. References

Foken, Th., Weisensee, U. , 1998: vergleich von Ultraschallanemometern vom Typ Kaijo-Denki DAT- 310/A. In: Foken, Th. (Ed.): Ergebnisse des LINEX-97/1 Experimentes. Deutscher Wetterdienst, Abteilung Forschung, Arbeitsergebnisse, No. 53, 6-9.

Foken, Th., Tsvang, L. R., Zubkovskij, S. L., Zelený, J., 1994: Results of turbulence comparison experiments in the middle and east European countries 1981 - 1990. Deutscher Wetterdienst, Abteilung Forschung, Arbeitsergebnisse, No. 9, 22 pp.

Foken, Th., Weisensee, U., Kirzel, H.-J., Thiermann, V., 1997: Comparison of new-type sonic anemometers. Preprint volume of the 12th Symposium on Boundary Layers and turbulence, 28 July - 1 August 1997, Vancouver Canada, Am. Meteorol. Soc., Boston, 356-357.

Hanafusa, T., Fujitani, T., Kobori, Y., Mitsuta, Y., 1982: A new type sonic anemometer-thermometer for field operations. Papers in Meteorol. & Geophys., 33,1-19 Fig.

Young Company, 1999: Model 81000 ultrasonic anemometer. Manual PN 81000-90, Traverse City, MI, 4 pp.

5. Symbols

R	correlation coefficient
T_a	sonic temperature
v_h	horizontal wind velocity
w	vertical wind velocity
σ_{Ta}	standard deviation of the sonic temperature
σ_{vh}	standard deviation of the horizontal wind velocity
σ_w	standard deviation of the vertical wind velocity

Nr	Name	Titel	Datum
01	Foken	Der Bayreuther Turbulenzknecht	01/99
02	Foken	Methode zur Bestimmung der trockenen Deposition von Bor	02/99
03	Liu	Error analysis of the modified Bowen ratio method	02/99
04	Foken et al.	Nachtfrostgefährdung des ÖBG	03/99
05	Hierteis	Dokumentation des Expertimentes Dlouha Louka	03/99
06	Mangold	Dokumentation des Experiments am Standort Weidenbrunnen, Juli/August 1998	07/99
07	Heinz, Handorf, Foken	Strukturanalyse der atmosphärischen Turbulenz mittels Wavelet-Verfahren zur Bestimmung von Austauschprozessen über dem antarktischen Schelfeis	07/99
08	Foken	Comparison of the sonic anemometer Young Model 81000 during VOITEX-99	10/99