Field comparison of different raingauges and present weather sensor at MHS of Croatia

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ABSTRACT

The Meteorological and Hydrological Service (MHS) of Croatia started in May 2004 field comparison of three different tipping-bucket raingauges with heating, an ordinary raingauge, a float raingauge and the present weather sensor. All detectors were mounted at the test field at Meteorological Observatory Zagreb Maksimir. The tipping bucket raingauges were equipped with the data loggers and the GSM interfaces that enabled full remote control. Stored data as the one-minute amounts were transferred to the remote center at MHS every hour when there was a rain. The main objectives of the comparison were to test a response of different raingauges, to control the measured amounts of precipitation during rain showers and light rain, and to find an influence of a high wind speed on the measured amounts. The comparison was very helpful for a selection a reliable instrument for desired geographical region, an interpretation of present weather sensor data and for involving these instruments in the network of automated weather stations in Croatia.

Introduction

In early nineties of 20th century MHS started to develop automatic weather stations (AWSs) and a telemetric system (network) for remote transfer of data in close co-operation with domestic manufacturer *Tritonel multimedia*. Number of AWSs was constantly growing and AWSs have been used for MHSs purposes as well as to meet special needs of different users for different measurements, like temperature measurement on special ships, wind measurement on bridges and towers, etc.

Nowadays MHSs network of AWSs consists of 65 stations that are reachable 24 hours per day via fixed telephone, GSM or internal network. Measured data as the 10-min records are transferred to the main database at central building of MHS in Zagreb at different time interval from 30 min to 1 day. Most of the AWSs are also equipped with different raingauges. Due to difficulties experienced in precipitation measurement, MHS decided to test few of the available raingauges with the aim of finding the most suitable raingauge for our geographical regions.

Test field and measuring systems

Meteorological and aerological Observatory Zagreb Maksimir is located in the east part of Zagreb. Meteorological measurements and observations were started early after second world war and have continued till nowadays. The crew of 10 people performs standard meteorological measurements and observations 24 hours per day with pilot balloon and rawinsonde observations twice per day. In front of the building there is a large, newly built, meteorological examination field with electricity and other infrastructure that enables a testing of different meteorological instruments or automatic weather stations.

This field is used for the testing of different tipping bucket raingauges (Figure 1.) that are aimed to be added to automatic weather stations. According to the possibilities, three different manufacturers were chosen (Table 1.).

Figure 1. Tested rain gauges at meteorological observatory Zagreb – Maksimir

The tipping bucket raingauges were equipped with the processor module and data logger (Figure 2.), type a-ombro (*Tritonel Multimedia, Croatia*) that enables storage of one-minute amounts in real time during the rainfall. The storage capacity can accumulate six months of the one-minute data samples. GSM interface assures full remote control and data transfer. Automatically, the data were transferred to the main database at central building of MHS in Zagreb every hour, during rainfall. The available power supply is 220 V or 12 V according to the demand of the manufacturer.

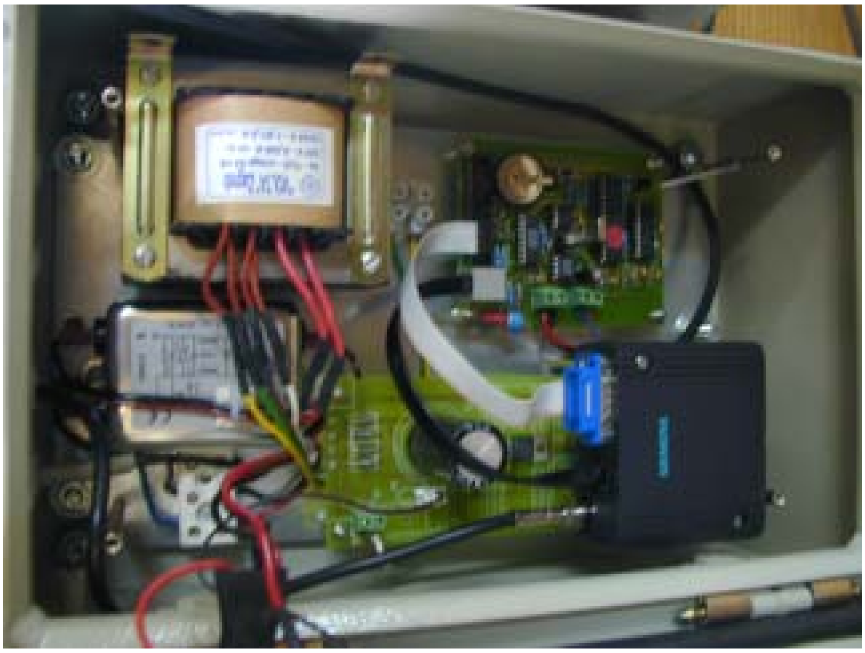

Figure 2. Processor module and data logger, type a-ombro (*Tritonel Multimedia, Croatia*)

All raingauges were calibrated by the manufacturer and checked before start of their operation. Routine maintaining procedures were performed regularly as it was suggested by user manuals.

Table 1. Technical characteristics of tested raingauges

producer	type	measuring system	orifice			resolution (mm)	heating (W)
			area (cm^2)	type of material	h (m)		
Lambrecht, Germany	1518 H3	tipping bucket	200	aluminium	1,5	0,1 ± 2%	235
Meteoservis, Czech Rep.	MR3H-F	tipping bucket	500	aluminium	1,5	0,1 ± 2%	57
Young, USA	M52202	tipping bucket	200	plastic	1,5	0,1 ± 2%	18
Lambrecht, Germany	1507A	float	200	zinc	1,5	0,1	160

Observational period

Operational mode of the raingauges started in April 2004. In these papers data from May till October are analysed. This period was chosen because no heating of instruments was required. All instruments have worked continuously without any data loss. All data were officially verified and are available as minute, hourly or daily sum.

Data analysis

Lambrecht float raingauge data was corrected and verified in comparison with ordinary gauge. These data are referred to as ordinary gauge data. All comparisons and deviations were calculated relatively to the ordinary gauge data. The data were analysed on monthly and daily basis. Amounts of precipitation recorded by tested instruments were compared during days with higher or lower amounts of precipitation. Finally, comparison with PWD sensor and analysis of the influence of higher wind speed was done.

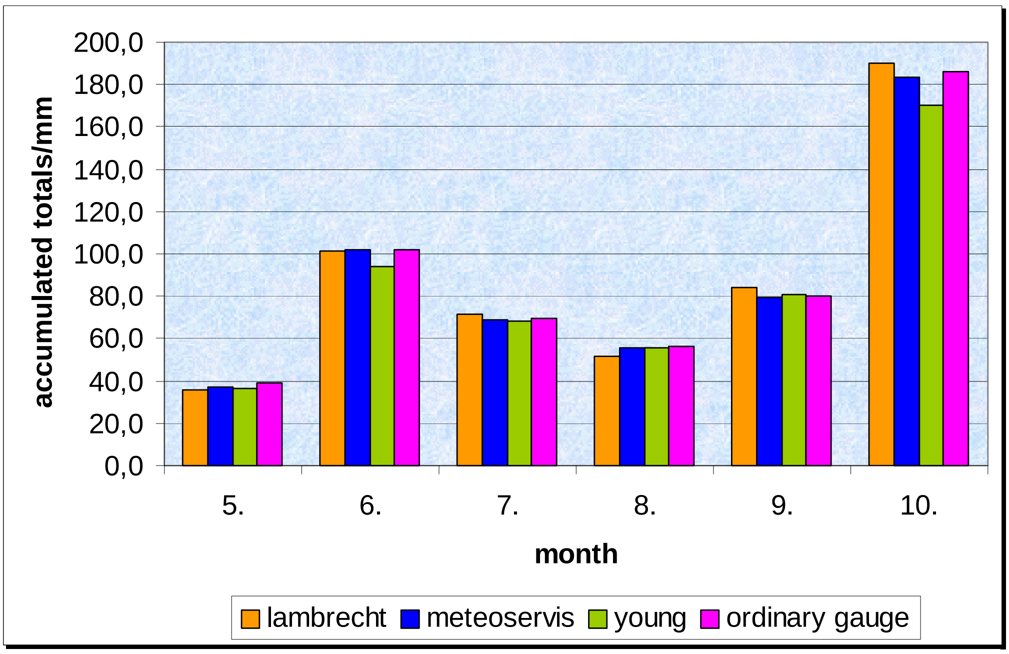

Figure 3. Accumulated totals of different raingauges for whole observed period

Monthly total amounts

Monthly total amounts (Figure 3.) show that during drier months, like in May, ordinary gauge has the largest value and Lambrecht raingauge the lowest one. In October when there was over 180 mm precipitation the highest amount was registered by Lambrecht raingauge and the lowest by Young raingauge. Meteoservis raingauge always recorded values somewhere in the average.

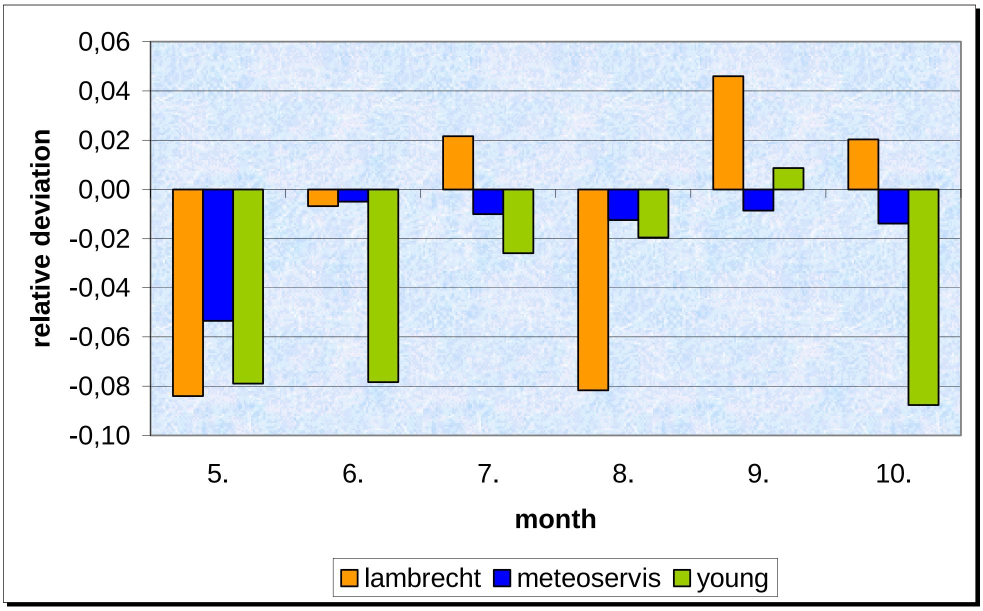

Figure 4. Relative deviations of different raingauges to the ordinary gauge for whole observed period

Relative deviation of tipping bucket raingauges is in most cases negative, which implies that tipping bucket raingauges underestimate precipitation. It is fully consistent with Young and Meteoservis raingauge relative deviations that have always negative values (Figure 4). Relative deviations of Young raingauge show the highest underestimation of measured precipitation, even up to 8 %. Meteoservis raingauge deviations are very uniform and below 2% with only one exception in May (the lowest monthly amount). It is found that Lambrecht raingauge deviations are as much positive as negative but absolute value of negative deviations is even two times greater than the value of positive deviations.

Daily deviations

Clear overview of daily relative deviations is seen on Figures 5. and 6. Mostly negative deviations support the fact seen from monthly totals that tipping bucket raingauges underestimate precipitation. The deviations are very often below 0.2, looking absolute values. There are few exceptions. One exception happened on 30th of May (Figure 5). The relative deviation for Meteoservis raingauge is 2.0 and for the others –1.0. Explanation is seen from the real data. There was very light rain and Meteoservis raingauge registered amount 0.3 mm, ordinary gauge 0.1 and other raingauges nothing. On 15th July only ordinary gauge registered precipitation with amount 0.6 mm. At the end of July there were two days with very light rain. The first is 27th; when Meteoservis raingauge registered 0.2 mm and others half of this, and on 29th all tipping bucket raingauges registered twice of ordinary raingauge amount that was 0.1mm. It could be said that Meteoservis raingauge has the best sensitivity among selected raingauges.

In October when it was very rainy, situation with daily relative deviations is different (Figure 6.). There are as much positive deviations as negative but looking absolutely positive are higher, even higher then 0.4.

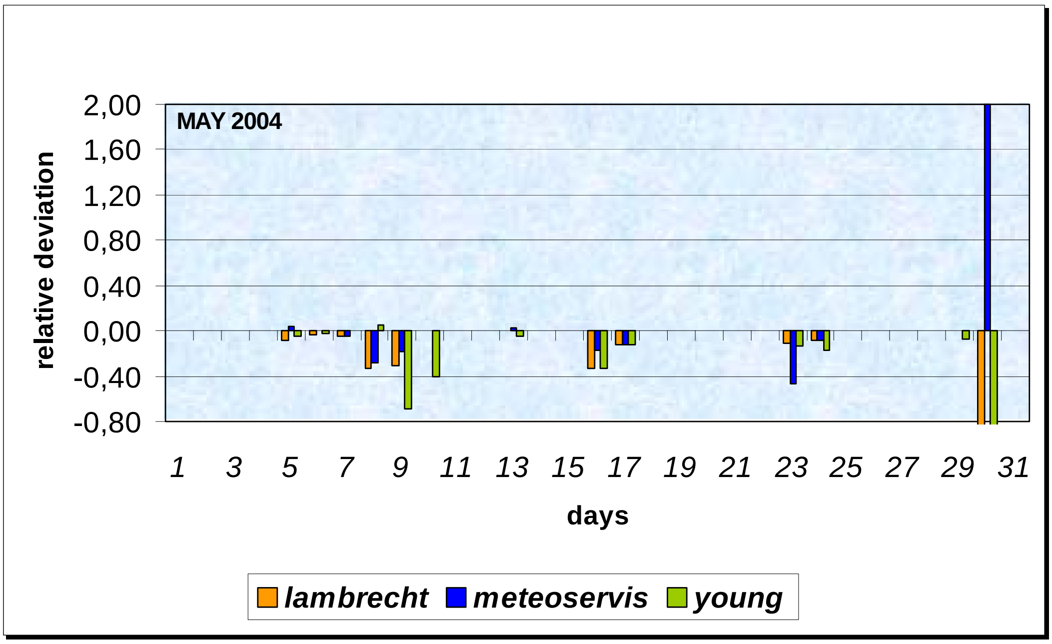

Figure 5. Relative deviations of different raingauges to the ordinary gauge for May

According to this it can be concluded that during light rain tipping bucket raingauges underestimate precipitation, but during very rainy conditions they overestimate it.

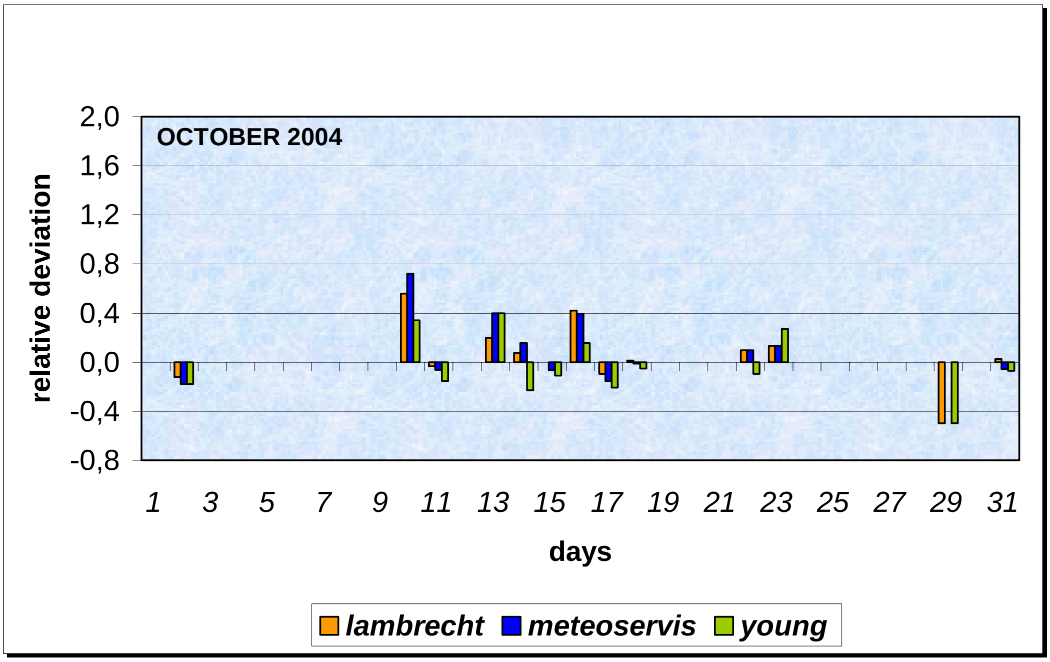

Figure 6. Relative deviations of different raingauges to the ordinary gauge for October

The analysis of the range of the relative deviations is shows on Figure 7. Ends of the bar represent values mean ±1 standard deviation, respectively. Higher dispersion of the relative deviations is seen for all raingauges in May and July and this is probably due to lower amounts of precipitation In these months the highest dispersions and the positive averages of relative deviations are found for Meteoservis raingauge which support the fact that it showed the best sensitivity. In other months dispersion of Meteoservis raingauge is the lowest and Lambrecht raingauge the highest. Average relative deviations of Lambrecht and Meteoservis raingauges have positive and negative values while Young raingauge is significantly negative but generally with the lowest dispersion.

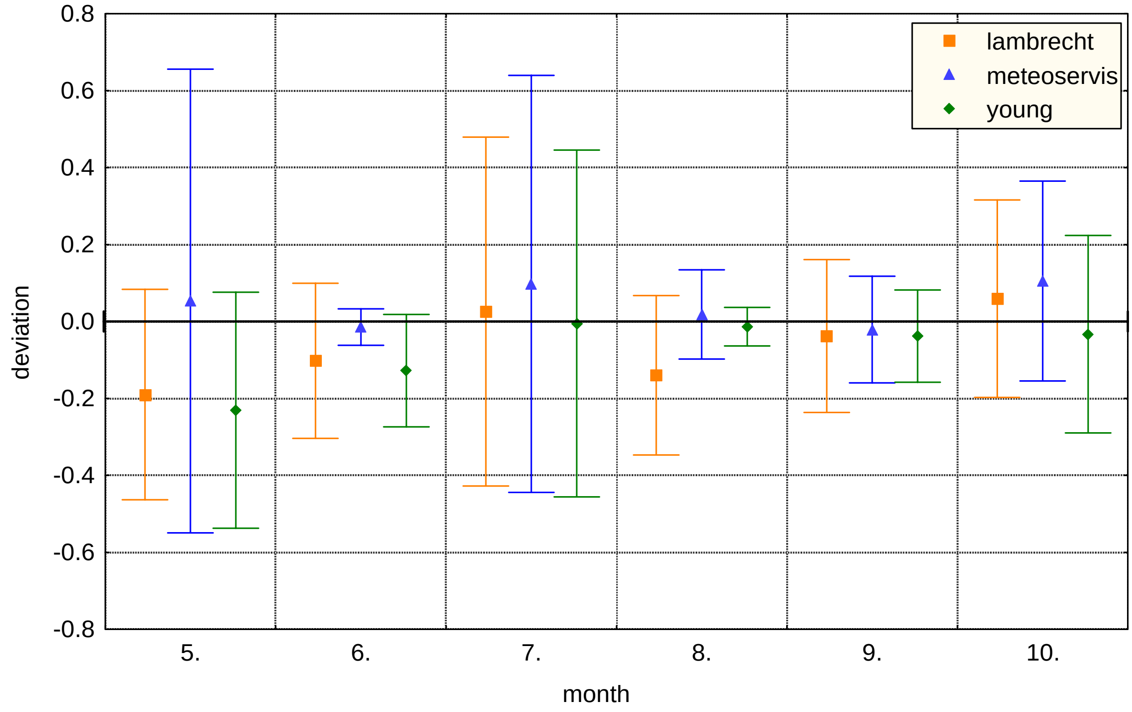

Figure 7. Dispersion (mean +/- 1 stdev) of relative deviations of different raingauges

Comparison during showers and light rain

Only the days with precipitation lower than one mm and higher than twenty mm were taken in consideration as light rain or shower days, respectively. During light rain days (Figure 8.) the deviations were also mostly negative. Only in 25% of the selected days deviations were positive, among which Meteoservis and Lambrecht raingauges overestimated precipitation three times and Young only two times.

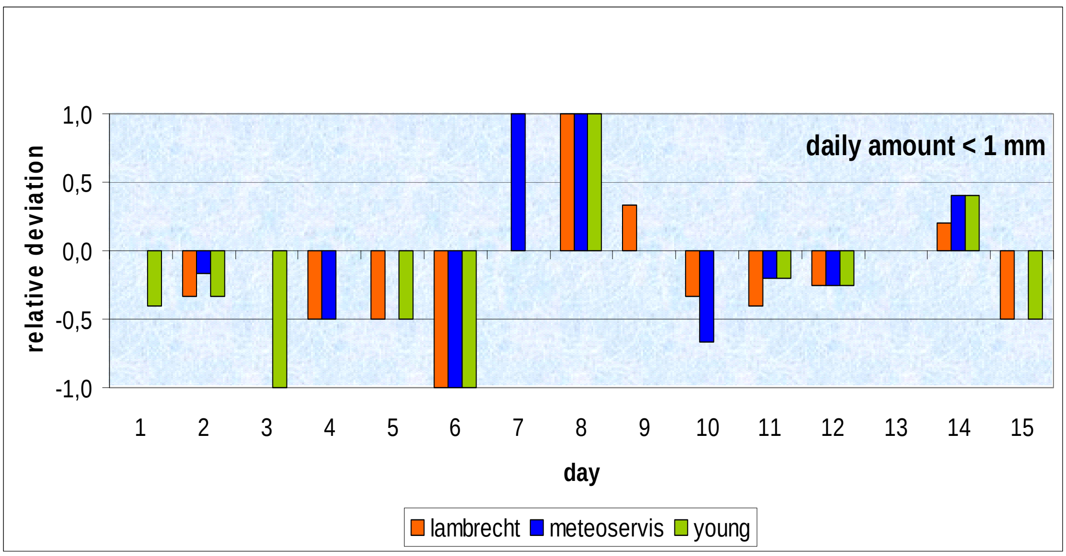

Figure 8. Relative deviation for measured precipitation (daily amount < 1 l)

Only once, tipping bucket raingauges registered precipitation and ordinary raingauge didn't, and vice versa. There was one day when only Meteoservis raingauge registered precipitation.

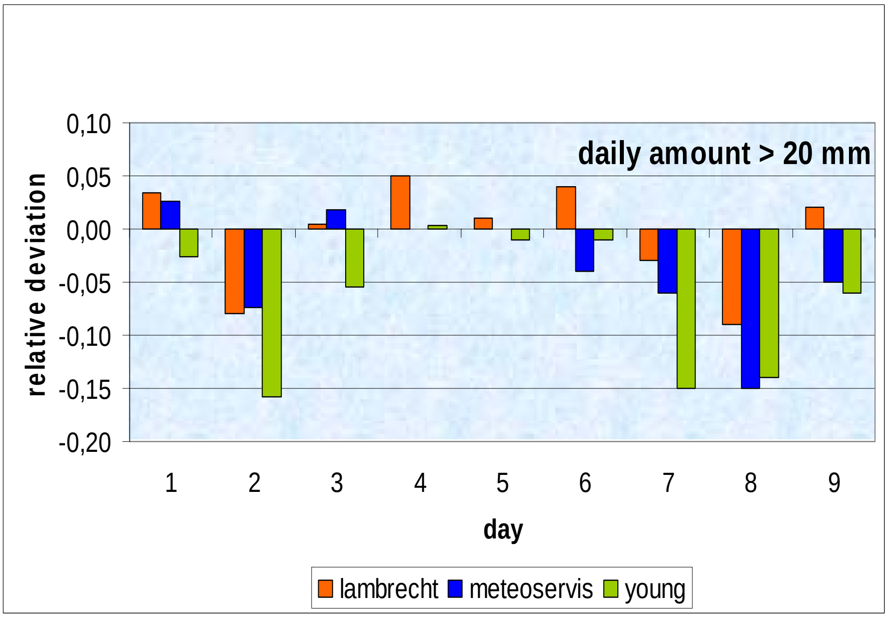

Figure 9. Relative deviation for measured precipitation (daily amount > 20 l)

During shower days there were as much positive as negative deviations (Figure 9). Negative deviations were higher values on absolute scale. Young raingauge consistently underestimated precipitation. Lambrecht raingauge on the other hand doesn't show any regularity in deviations. Comparing intensities in mm/h it was found that the most frequent intensity was 6 mm/h what corresponded to very often registered amount of 0.1 mm. The highest intensities were registered most frequently by Lambrecht, then Meteoservis and then Young raingauge.

Comparison with PWD at higher wind speed

Earlier practice showed that at very high wind speeds Young raingauge registered precipitation even when there wasn't any precipitation.

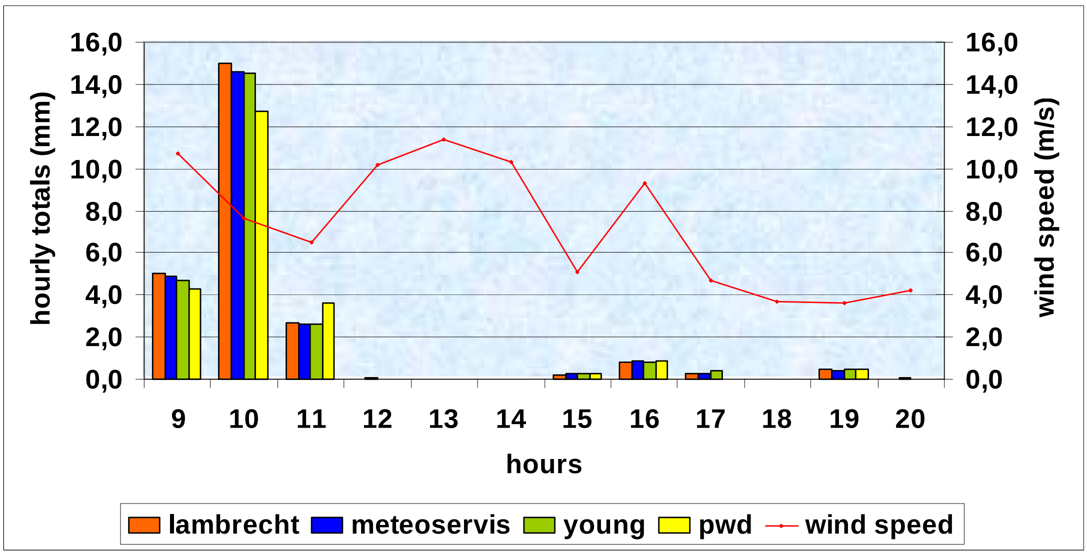

Figure 10. Hourly totals and associated wind speed for selected day, 26[th] August 2004.

Additional observations and analyses of other meteorological parameters led to conclusion that the main reason for the “precipitation” were vibrations of light plastic raingauge due to high wind speed. Fixing of the raingauge body eliminated the problem. That was the reason why the days with higher wind speed are taken in consideration (Figure 10.). As it was already seen at higher intensities Lambrecht raingauge registered the highest amounts, then Meteoservis and then Young. At lower intensities Lambrecht registered less than Meteoservis and Young. Any clear influence of wind speed on registered amounts couldn’t be directly found due to the lack of very windy days with precipitation.

Although there were some technical problems in transformation of the data of PWD21 (*Vaisala, Finland*) sensor, an initial comparison was done. PWD sensor in most cases registered the lowest amounts especially during higher intensities. There were just very single cases when the situation was different, but generally it could be said that PWD sensor underestimates precipitation.

Conclusions

In analysed period it was found that generally tipping bucket raingauges underestimate precipitation. Due to relative deviations comparison it could be said that Young raingauge showed the highest underestimation of measured precipitation but also the lowest dispersion of the deviations. Very high uniformity and the highest sensitivity in registration were found for Meteoservis raingauge and its registration was the closest to the ordinary gauge. Although Lambrecht raingauge registered the highest amounts, its registration deviations showed the least regularities. Daily analysis helped in finding that during light rain tipping bucket raingauges underestimate precipitation, but during very rainy conditions they overestimate it.

Comparison with PWD sensor showed that in most cases PWD sensor registered the lowest amounts, especially during higher intensities and higher wind speed.

Further comparisons and investigations especially with main emphasis on the influence of the heating will be done.

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