Correction of in–situ rainrate measurements at high wind speeds

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Introduction

Mechanical raingauges tend to underestimate the local rainrate because of wind induced errors (e.g. Folland, 1988), outsplashing- and wetting effects. So does the ship-borne raingauge from the IfM / Kiel (Hasse et al. 1993, this Volume). In comparison with other mechanical raingauges, however, this instrument has been designed for usage at wind speeds up to 25 m/s. Under such windy conditions the wind induced error is several magnitudes larger than the other errors mentioned before. Thus the total error can be expressed as a function of the local wind speed only. A simple algorithm to estimate the wind induced error can be written as

$$\Delta RR = a \cdot U^m \cdot RR$$

where U designates the local wind speed and RR indicates is the amount of water falling onto the horizontal sampling area. Correction of the measurements of the vertical sampling area are perfomed analogously. In order to obtain reliable values for the parameters a and m the IfM – Optical Disdrometer (Hasse et al. 1993, this Volume) had been used for simultaneous measurements together with the mechanical gauge on board RV 'ALKOR' during a 6 days cruise north of Denmark in Nov 1992. Hauser et al. (1984) and Illingworth et al. (1987) showed that even sophisticated optical raingauges are influenced by physical effects leading to biased results which require correction.

Correction of disdrometer data

Measurements made using the IfM – Optical Disdrometer include a random sampling error as well as systematic errors caused by

- overestimation of the transition time
- oblateness of the drop–shape
- multiple occupancy of the sensitive volume by raindrops
- grazing incidence.

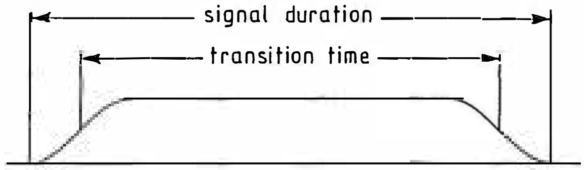

Figure 1: sketch of an electronic signal caused by a drop falling through the sensitive volume

Figure 1 illustrates that the transition time of a raindrop is always smaller than the duration of the corresponding electronic signal. This effect is being compensated by multiplying the signal duration by $\frac{D}{D+d}$, where D represents the diameter of the sensitive volume and d is the diameter of the falling drop.

The effect of drop–shape–deformation can be taken into consideration using the formulae given by Pruppacher and Pitter (1970). Since the signal of the optical disdrometer is proportional to the area of a drop's crossection, the area of a falling drop had been calculated as a function of the area of a spherical drop with the same volume.

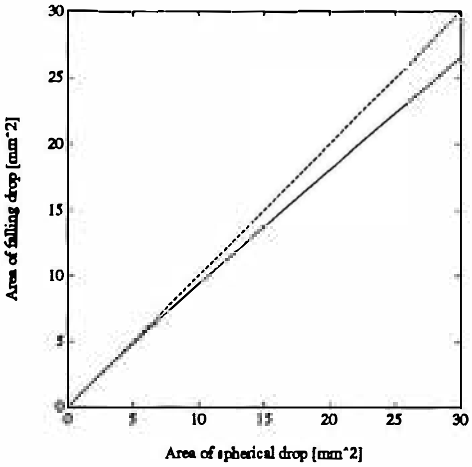

Figure 2: effect of an oblated dropshape on the area of a drop's crossection

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These calculations are being used to correct the raw data of the disdrometer in order to obtain true raindrop size measurements.

In order to deal with the errors caused by multiple occupancy and grazing incidence a computer modelling of these effects has been performed. The model assumes uniform distribution of the drops above the sensitive volume according to a Marshall–Palmer–dropsize distribution.

Results

The results of the computer modelling are presented in figure 3. This figure shows that the error caused by multiple occupation not only depends on the rainrate but also on the wind speed, because the likelyhood for multiple occupancy increases with decreasing wind speed.

The correction of the disdrometer data as described before makes it possible to use this instrument for calibration of the ship–raingauge.

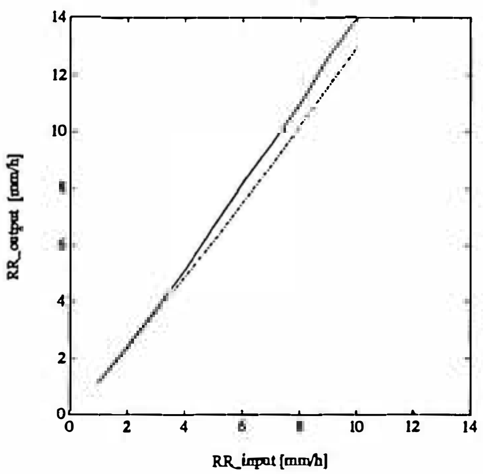

Figure 3: effect of multiple occupancy and grazing incidence under different external conditions. The solid line indicates $U = 0\ m/s$; the dash-dotted line $U = 20\ m/s$

Applying the technique of nonlinear regression leads to the following parameters, which are used to correct for the wind induced error at the horizontal sampling area of the ship–raingauge: $a = 4.86E-4$ and $m = 2$.

A similar correction should apply for typical land based raingauges, too. The same technique is also used to correct for the wind speed dependent change of effective crossection of the vertical collecting surface of the ship–raingauge. Further results and more detailed description of the methods used are given on the poster.

References

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