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Rain drop size densities over land and over sea

Karl Bumke

Leibniz-Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel Düsternbrooker Weg 20, D-24105 Kiel, Germany (kbumke@ifm-geomar.de)

A detailed knowledge of rain drop size densities is an essential presumption with respect to remote sensing of precipitation. Since maritime and continental aerosol is significantly different yielding to differences in cloud drop size densities, maritime and continental rain drop size densities may be different, too. In fact only a little is known about differences in rain drop size densities between land and sea due to a lack of suitable data over the sea. To fill in this gap measurements were performed during the recent 10 years at different locations in Germany and on board of research vessels over the Baltic Sea, the North Sea, Atlantic, Indian, and Pacific Ocean. Measurements were done by using an optical disdrometer (ODM 470, Großklaus et al., 1998), which is designed especially to perform precipitation measurements on moving ships and under high wind speeds. Temporal resolution of measurements is generally 1 minute, total number of time series is about 220000.

To investigate differences in drop size densities over land and over sea measurements have been divided into four classes on the basis of prevailing continental or maritime influence: land measurements, coastal measurements, measurements in areas of semi-enclosed seas, and open sea measurements. In general differences in drop size densities are small between different areas. A Kolmogoroff Smirnoff test does not give any significant difference between drop size densities over land, coastal areas, semi-enclosed, and open seas at an error rate of 5%. Thus, it can be concluded that there are no systematic differences between maritime and continental drop size densities. The best fit of drop size densities is an exponential decay curve,

$$N(D) = 6510 m^{-3} mm^{-1} mm^{0.14} h^{-0.14} \cdot R^{-0.14} \cdot \exp(-4.4 mm^{0.25} h^{-0.25} \cdot R^{-0.25} \cdot D\, mm^{-1}),$$

it is estimated by using the method of least squares. N(D) is the drop size density normalized by the resolution of the optical disdrometer, D the diameter of rain drops in mm, and R the precipitation rate in mmh^{-1}.The precipitation rate dependent factor in the exponential is similar to that given by Marshall and Palmer (1948). The intercept parameter, in the original Marshall Palmer formulation not depending on the rain rate, is also of the same order.

A number of recent publications have shown that drop size densities of convective and stratiform rain show significant differences, too. Several procedures have been developed in the past to decide, whether precipitation is of stratiform or convective character. Here two of them are used, temporal variability in rain rates and additional information by weather radar data for the South Western Baltic Sea.

Main result is that differences in drop size densities depend on the integration time of measurements. For integration times of 1 minute no significant differences can be detected at an error rate of 5%, while integration times of 10 minutes yield to significant differences between drop size densities of prevailing stratiform and convective rain.

References:

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Marshall, J.S. and W.M.K.Palmer, 1948: The distribution of rain drops with size, J. Meteor., 5, 165-166