8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-104

Covariation of droplet size distribution and air humidity in fog: A methodological approach

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The dynamics of a particle, for example of a fog droplet, depends on its size. Further, we see that clouds or fogs are not homogeneous bodies, but contain air masses with higher-than-average relative humidity (RH) and other air masses with lower-than-average RH. Therefore, it is interesting to analyze the droplet size distribution (DSD) in clouds and fog in covariation with the air humidity. However, some instrumental challenges arise, particularly with respect to the high-precision measurement of RH. The approaches made so far include, for example, infrared absorption techniques in airborne cloud physics studies.

A new method was developed and employed for the first time in March and April 2017 on Mt. Lulin, Taiwan. This method allows the calculation of relative humidity in the droplet-free air of fog and, in a further step, links this data to the DSD as measured with a FM100 Fog Monitor. The setup consists of a newly developed fog droplet separator with an attached H_2O gas analyzer and precision thermometer. The fog droplet separator works similar to an active fog collector, yet with a high collection efficiency of 98.3 % for the liquid water content. The water vapor concentration and the temperature can be measured precisely and without essential disturbance by fog droplets at a frequency of 1 Hz in the droplet-free air. The DSD was analyzed and its covariation with RH was studied.

Regarding a single fog event, there are differences in the DSD between data with high RH ($>$ 100.3 %) and low RH ($<$ 99.7 %). However, when considering all data of a fog event, the DSD is quite similar. Note that the droplet diameters are generally high regarding the Köhler curves. The geometrical means of the droplet diameters are 9.2 μm and 9.3 μm for the DSD of the two analyzed fog events, respectively. This may implicate that the dry diameters of the condensation nuclei and the salinity are relatively high. The hypothesis of the Köhler curve stating that droplets are smaller at a low RH than at a high RH is confirmed in one of the two analyzed fog events.

The results show that the developed method is appropriate to analyze the DSD in covariation to the air humidity in fog. However, this covariation is complex: the analysis of more fog events and measurements with a higher resolution, especially for the DSD of the smaller droplets, is inevitable.