Leaf Wetness :
now a quantifiable parameter in deposition studies

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What is leaf wetness?

Obviously, "leaf wetness" is liquid water that is present on a leaf surface. It may be a droplet originating from the deposition of rain or fog; it may also be condensed water that either originates from the atmosphere ("dew") or that exited the interior of the leaf through the stomatal transpiration. Hydrophilic aerosol particles on the leaf surfaces may deliquesce (= take up humidity from the gas phase) at relative air humidities below 100%, and thus support or enable the formation of leaf wetness. Films of leaf wetness on plant surfaces may be as thin as a few nanometers.

The importance of leaf wetness in deposition studies

Various atmospheric trace gases with moderate or high water solubilities (*e.g.*, SO_2) deposit more efficiently to wet leaf surfaces than to dry surfaces. Therefore, leaf wetness is an important parameter in modelling atmospheric depo-sition of trace gases. Adequate estimates of leaf wetness will increase the quality of gaseous deposition models.

The measurement of leaf wetness

Leaf wetness is measured with clip sensors that detect the electric conductivity of the leaf surface between two gold electrodes. The resulting data are not unambiguously interpretable. Especially inter-sensor variability is high. Every clip sensor detects a different conductivity signal depending on its contact area with the leaf. Therefore, the raw data have to be intercalibrated. The scope is to find an arbitrary measure that characterizes the leaf wetness of the canopy.

Data reduction and compilation

We use the responses of various (n=6) leaf wetness sensors and meteorological data (relative humidity and precipitation) to compute a single leaf wetness parameter. A time period of at least 2 months is used for these calculations. Our two underlying assumptions are (i) that significant precipitation (0.1mm) always leads to wet surfaces, and (ii) that the leaves are dry whenever the atmosphere is very dry (*e.g.*, relative humidity < 40%). We perform our data compilation and reduction in 6 steps:

1. All raw data of the clip sensors are quality checked, especially times of apparently missing or bad contact between sensor and leaf have to be disregarded.

2. Determination of the zero signal for each sensor, *i.e.* the electrical conductivity of the dry leaf surface. It is determined through interpolation of the conductivities that were observed during times with relative air humdity < 40%. The raw data are corrected for zero signals.

3. Determination of the accumulated time period of precipitation. For example, it may have rained during 10% of the time during the experimental period. Fog events may be defined as precipitation events in this sense.

4. Determination of the signal percentile for every sensor that statistically represents the periods of precipitation, in our example 90%. In average, the data above the precipitation percentile should have been measured during precipitation, and the data below the precipitation percentile outside precipitation periods.

5. Slope correction of the signals by dividing all zero-corrected raw data by the value of the resepective precipitation percentile (in our example: 90%). Now we have values between about zero and about one for each sensor

6. Averaging of these single sensor signals. Values above one are set to one, and those below zero are set to zero. The result is a single leaf wetness parameter between 0 and 1.

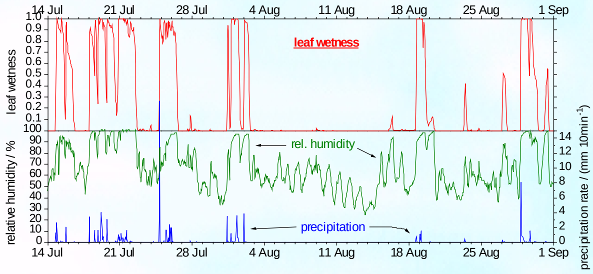

Fig. 1: Leaf wetness at our forest research site in NE Bavaria between 14 May and 31 August, 1997.

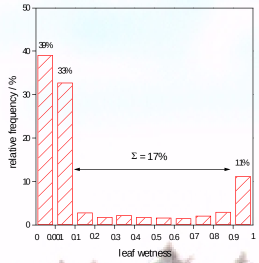

Fig. 2 shows that only a total of 50% of the data represent conditions of either very dry or very wet leaf surfaces. During 33% of the time low leaf wetness between 0 and 0.1 was observed. It is important to note that these leaf wetness data are significantly different from zero.

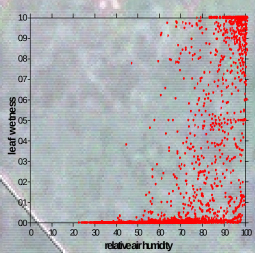

Fig. 3 shows that there is no close correlation between leaf wetness and air humidity. Low leaf wetness occurs almost over the entire air humidity spectrum, a cloud of data points is at high leaf wetness and high air humidity, respectively. However, the entire range of moderate leaf wetness is broadly scattered within the range of relative air humidity > 50%.

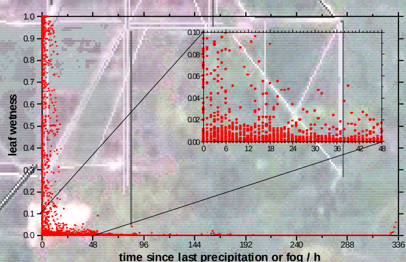

Fig. 4 indicates that high leaf wetness is always correlated with precipitation and that it drops to values below lw = 0.1 within about 24 hours time. However, low leaf wetness (0.001 < lw < 0.1) frequently occurs within 48 hours after precipitation and in some cases seem not to be correlated to any precipitation at all. The processes and conditions leading to these phenomena deserve further investigation.

Conclusions, open questions, what is left to do ?

We have introduced leaf wetness as an operational parameter in deposition models at least on a semi-quantitative basis. The limitation of its applicability lays mainly in the fact that there is no unbiased relationship between our leaf wetness parameter and the amount of liquid water present on the leaves (water film thickness). The direct application of the leaf wetness parameter in deposition models (*e.g.*, inferential models) is presently limited to the application of some background assumptions, *e.g.*, *the influence of leaf wetness on deposition is independent of its pH*, or, *the capacity of leaf wetness to take up soluble gases is a direct function of the measured leaf wetness parameter*. We will test the concept and its applicability in various ecosystems and using various deposition models. Another focus of our future studies will lay in the role of atmospheric boundary layer turbulence in the formation and dissipation of leaf wetness.

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• Check out our meteorology and air chemistry informations at http://www.bitoek.uni-bayreuth.de/

• the background picture shows our tower research site close to the "Waldstein" summit, Fichtelgebirge mountains, NE Bavaria, at 765 m a.s.l., 50°08'40"N, 11°51',55"E.