Dependence of the Canopy Resistance on Environmental Parameters

1. Introduction

Because the grass canopy at the experimental site was treated with a broad-spectrum herbicide (glyphosate) one week before the start of the experiment, the stomatal conductance was assumed to be zero and the canopy resistance R_c was reduced to the non-stomatal (cuticular) resistance R_w. Several environmental factors influence the magnitude of dry deposition removal [1, 2] and therefore the magnitude of R_w. Amongst the most prominent ones are the relative humidity (RH), the air temperature (T) and SO_2 co-deposition. For the following analysis, RH and T were extrapolated from the measurements on-site at 1.25 m above ground level (a.g.l.) to the corresponding values at a height of $d + z_0$.

2. Relative Humidity

An increase in relative humidity enhances the H_2O content on absorbing surfaces, which favors deposition of NH_3 onto the surface. A log-linear relationship has been suggested to appropriately describe the dependence of R_w (and therefore, in the present case, also the dependence of R_c) on RH [e.g. 3]:

$$\ln(R_w) = \ln(R_{w,min}) + a(100 - RH), \tag{1}$$

where RH is the relative humidity given in %, and the minimum cuticular resistance $R_{w,min}$ (as well as the cuticular resistance R_w itself) is given in s m^{-1}. Table 1 in Massad et al. [4] summarizes possible values for parameters $R_{w,min}$ and a from different studies on grassland sites. We took the published responses of R_w on the changes in RH (i.e. parameter a for type *grassland* and specifications *agriculture*) and fitted Equation (1) to our 'best estimate' values R_c^1 (see main paper, Section 2.4.7 and Table A1 in the Appendix) with $R_{w,min}$ as a free parameter, by minimizing the difference between the fitted values and R_c^1 on a logarithmic scale (Figure 1). The log-linear RH dependency is not capable of appropriately describing the variation in R_c^1.

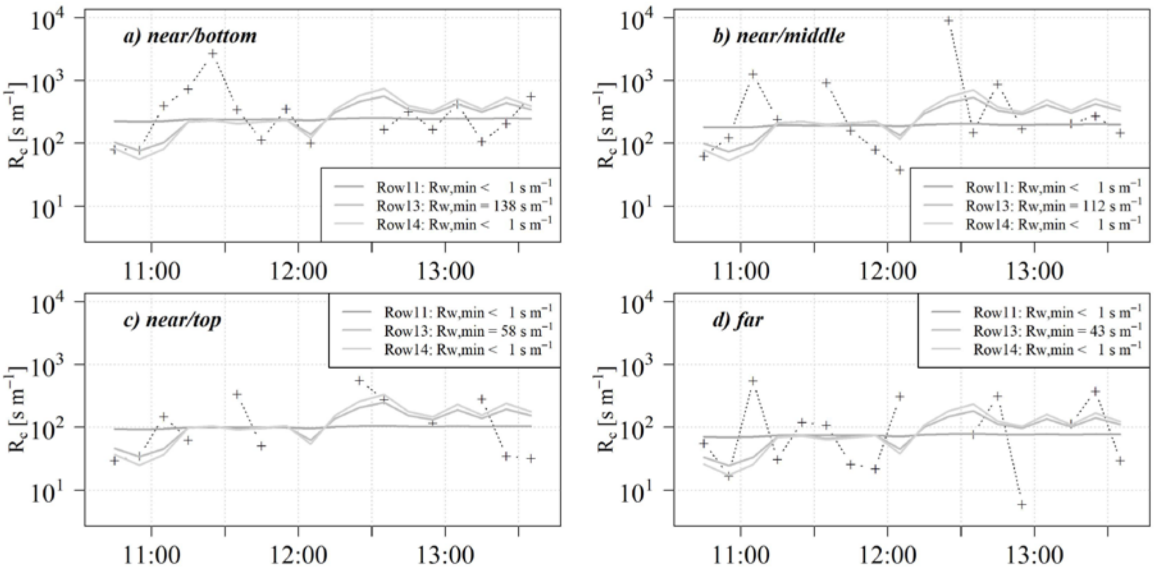

Figure 1. Fitted values of R_w ($\approx R_c$ in the present study) according to Equation (1) (grey lines) with corresponding estimates of $R_{w,min}$ (figure legend). Different greys correspond to different RH-responses as published on row 11, 13 and 14 in Table 1 of Massad et al. [4] (i.e. Row11: a = 0.143, Row13: a = 0.008, Row14: a = 0.110). Black crosses connected by a dotted line show the values of R_c^1

as estimated in the main paper (Table A1 in the Appendix). Panels a) - d) show results for the individual measurement locations.

3. Temperature

An extension of the dependence of R_w on air temperature and relative humidity was suggested by Flechard et al. [5] as:

$$\ln(R_w) = \ln\left(R_{w,min}\right) + a(100 - RH) + 0.15 \times |T|, \tag{2}$$

where RH is the relative humidity given in %, T is the air temperature in °C and R_w and $R_{w,min}$ are the (minimal) cuticular resistances given in s m^{-1}. The dependence of R_w on RH and T seems to (partially) reproduce the variation in the R_c^1 estimates (Figure 2).

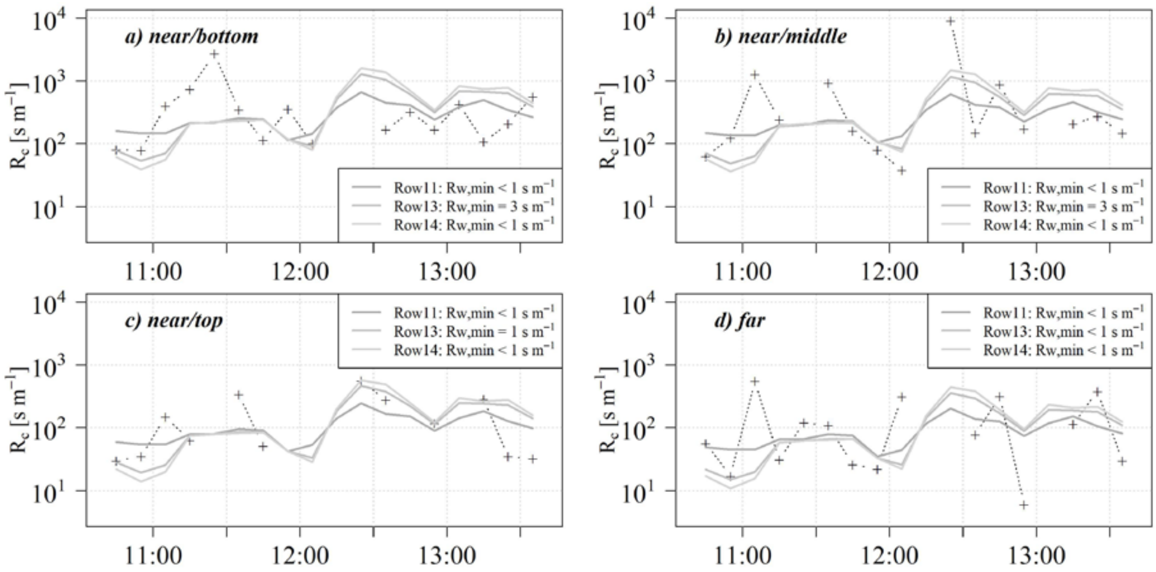

Figure 2. Fitted values of R_w (≈ R_c in the present study) according to Equation (2) (grey lines) with corresponding estimates of $R_{w,min}$ (figure legend). Different greys correspond to different RH-responses as published on row 11, 13 and 14 in Table 1 of Massad et al. [4] (i.e. Row11: a = 0.143, Row13: a = 0.008, Row14: a = 0.110). Black crosses connected by a dotted line show the values of R_c^1 as estimated in the main paper (Table A1 in the Appendix). Panels a) - d) show results for the individual measurement locations.

4. Ambient SO_2 Concentration (Co-Deposition)

Equation (2) was further extended by a dependence on the ambient SO_2 concentration, adapted from Simpson et al. [6] as:

$$\ln(R_w) = \gamma - 2.556 \times \alpha_{SN}, \tag{3}$$

where γ refers to the R_w dependence on T and RH according to Equation (2) (i.e. the r.h.s. thereof) and α_{SN} refers to the molecular ratio of SO_2 to NH_3 as shown in Figure 3. Equation (3) (i.e. the dependence of R_w on RH, T and SO_2 co-deposition) seems to (partially) reproduce the variation in the R_c^1 estimates (Figure 4). The R_w dependence including the SO_2 co-deposition is slightly better reflecting the variation in R_c^1 compared to the dependence on RH an T alone (Figure 2).

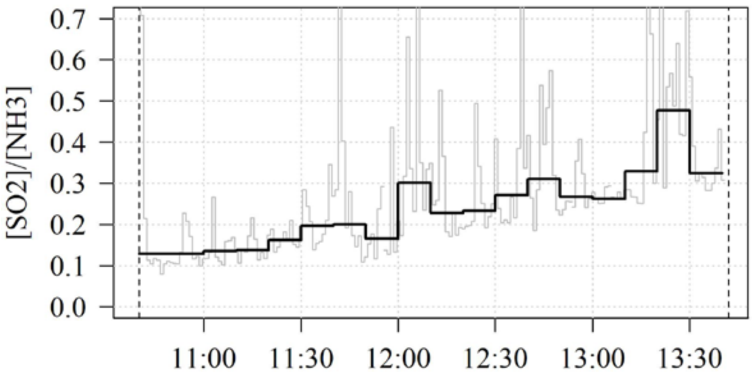

Figure 3. Molecular ratio of SO_2 to NH_3 (= α_{SN}) as measured during the NH_3 release experiment at a height of 0.5 m above ground level (location *near/bottom*).

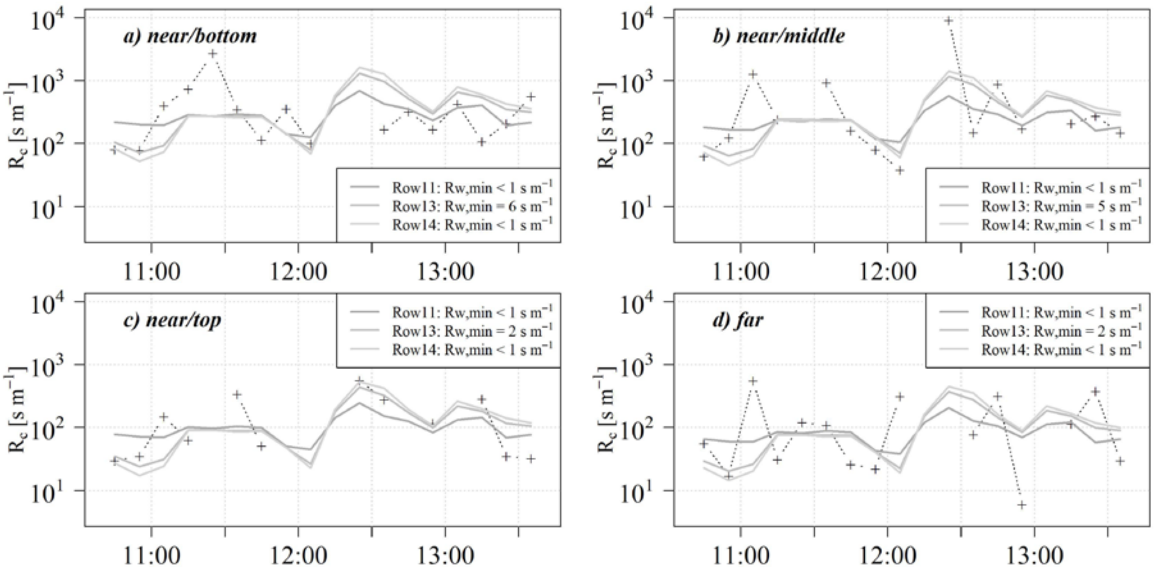

Figure 4. Fitted values of R_w (≈ R_c in the present study) according to Equation (3) (grey lines) with corresponding estimates of $R_{w,min}$ (figure legend). Different greys correspond to different RH-responses as published on row 11, 13 and 14 in Table 1 of Massad et al. [4] (i.e. Row11: a = 0.143, Row13: a = 0.008, Row14: a = 0.110). Black crosses connected by a dotted line show the values of R_c^1 as estimated in the main paper (Table A1 in the Appendix). Panels a) - d) show results for the individual measurement locations.

References

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