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Biogeosciences Discussions

Interactive comment on "Measurement and modelling ozone fluxes over a cut and fertilized grassland" *by* R. Mészáros et al.

R. Mészáros et al.

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We are grateful for the sound and useful comments of the reviewers. We have corrected the indicated technical corrections and typographical errors. Based on the suggestions of referees, the measured dataset has been revised, and new model simulations have also been carried out. Abstract, site and model description have been rewritten. Revision and extension of discussions has also been performed.

In the following we are addressing the specific points raised by the reviewers:

Answers to reviewer 1:

Major point: The NO flux can affect the ozone concentration. As the deposition velocity was calculated by the measured ozone flux and concentration, therefore NO flux also affects indirectly the deposition velocity.

Minor points:

(i) We agree that there is a strong correlation between precipitation and soil water content. However, despite the frequent rain events, the soil water content decreased during the measuring period because of higher temperature and higher evaporation in the second and third part of measurements. Evaporation from soil could be more effective after cut of the vegetation. As the soil water content measurement wasn't continuous, the effects of short precipitation events (showers) can't be seen in the time series of soil water content. Volumetric soil water content was measured in different depth by TDR (Time Domain Reflectometry). In the revised manuscript, the average of volumetric water content in 0-60 cm soil layer is presented in Fig. 1.

(ii) We have restructured Figure 2. Cut and fertilization are also marked in the figure.

(iii) P 1072 Eq 1: Units of <a> is ppb/mV, as <U> means the sensor output in mV.

Answers to reviewer 2:

- The calculation of stomatal flux is explained in more detailed. The stomatal flux has been calculated from Ft (total flux), obtained from measured concentration at a reference height and calculated deposition velocity. This flux was multiplied by Rc/Rst. Another way can be used to calculate the stomatal part of the flux (e.g. in EMEP model - www.emep.int), however, the two ways give the same results.

- According to the suggestion of another referee, another parameterization of cuticle and in canopy resistances has been used after Zhang et al. (2003).

- Model description has been shortened and restructured. Instead of Jarvis-type parameterization of stomatal resistance, this term has been calculated from the measured latent heat flux which was also available during the measuring campaign (Nemitz et al., 2009).

- Single-sided LAI is used in this calculation. LAI was measured in a few days during the measuring campaign and a simple function was fitted to measured values before

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and after cut based on vegetation height, which was continuously measured with a canopy height meter.

- Friction velocity (u*) is presented for three different period.

- p1077, section 4.1: The soil water content was sampled using TDR (Time Domain Reflectometry) at different soil depth. It is mentioned in the revised manuscript in the Section 2.2.

- p1077, section 4.1: LAI values have been corrected in the manuscript.

- p1078, section 4.2: We agree that no significant variations in wind speed among each period, and that soil moisture had a greater variability during the measuring period. We have reanalyzed the variables and parameters which affect the ozone fluxes. Section 4.2. has been restructured and rewritten.

-p1078 and 1079 Discussions: Based on the suggestions of referees, new model calculations have been performed and therefore the fractions of stomatal flux has been varied. Cuticle, in canopy and soil resistances have been parameterized by a more sophisticated way and dry and wet vegetation have also been distinguished. These modifications affected the fractions of ozone fluxes through the different ways.

-Discussions have been rewritten and extended.

Answers to reviewer 4:

1. The abstract has been rewritten according to suggestions of the reviewer.

2. A more detailed resistance network has been used in the new calculations using Zhang et al. (2003) resistance network.

3. This part of manuscript has been rewritten. A new model simulation has been performed.

4. This part of the manuscript has been rewritten.

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5. Section 4 and 5 have been combined into one section.

6. Sections 4, 5 and 6 have been rewritten according to comments of reviewer.

7. We agree that only very limited data are available, and therefore the results may be not statistically significant. However results can underlie the importance of non-stomatal resistance on ozone deposition. Results obtained from both measurements and modelling can contribute to the understanding of the soil-vegetation-atmosphere interactions.

8. Notation of each period has been rewritten according to the suggestion.

9. The text of the manuscript has been corrected.

Answers to reviewer 5:

(1) Ozone flux measurements

(a) We have clarified the location of the reference ozone monitor. The reference ozone concentration was measured at Broitzem urban background measuring site, 5 km from the flux site. We agree that this distance can cause some variations in the values of ozone concentration, however we assumed, that there are no significant differences between ozone concentrations in the background station and the flux site (Based on Diem (2003), the ozone measurements can be representative up to 10 km.). The environment of the flux site is flat and surrounded by arable and other managed grassland to the N, woodland, by grassland and sub-urban development to the E and S, and by experimental arable plots and a farm to the west. To consider the possible local effects, which can modified ozone concentration within this distance, and therefore influence the flux measurements, the measured flux values, when the correlation coefficient between reference ozone measurements and fast response ozone measurements was lower, than 0.8, were filtered.

(b) The fast response ozone sensor requires a calibration to evaluate the ozone flux. This calibration has been made by the reference ozone concentration. Measured deposition velocity has been calculated as the ratio of measured flux and measured reference ozone concentration. We have clarified it in the manuscript.

(2) Data processing

(a) The signal of the fast response ozone sensor was collected by an analogue channel of the Gill sonic anemometer at a frequency of 20.695 Hz. The air inlet tube of the fast response ozone sensor was 2 m long causing some time lag. Time lag for ozone measurement was estimated as the maximum of the covariance between the vertical wind speed and the ozone concentration using the 15 min averaging time. Vertical wind speed and ozone data sets were detrended in order to determine the time series of fluctuations by the moving average technique using a 400 s time window for the estimation of the mean values (McMillen, 1988).

(b) We have justified the ignorance of WPL correction for heat in the revised manuscript: The NOAA fast response ozone sensor is a closed path type sensor. The diameter of air inlet tube was 3 mm and the flow rate was approximately 0.6 L/min. If the trace gas concentrations are determined by closed-path gas analyzers, where the respective trace gas is brought to a common temperature and pressure within the optical bench, then there is no need for a correction associated with the transfer of sensible heat (Grunhage et al., 2000).

(3) Data analysis

(a) New model estimations have been performed and new results are discussed in detailed in the manuscript.

(b) We agree that water vapour flux is commonly used to estimate the stomatal resistance. For water vapour, if it is assumed that over a transpiring canopy with dry leaf surfaces, the bulk of the latent heat flux is transported via the stomatas, then it is possible to calculate a bulk stomatal resistance, as it was also carried out during the measuring period (see Nemitz et al., 2009.). We have calculated the deposition

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velocity and ozone flux using stomatal resistance estimated from latent heat flux.

(4) Deposition modelling

(a) We have described all model parameters in the revised manuscript and we have also analyzed how these parameters affected the deposition velocity.

(b) All used model parameters based on literature data. In this study, the values of model parameters have been obtained from Zhang et al. (2003) in almost all cases. However, the soil resistance has been parameterized with a simple linear function instead of a constant value, considering the effect of soil water availability.

(c) In several deposition models, the cuticle and soil resistances are constant, and not consider the difference between dry and wet surfaces. In the new model calculations, instead of former parameterization of Rcut and Rinc a more sophisticated parameterizations have been used and discussed.

(5) Presentation

(a) The site description has been extended (Section 2.1). Model description has been shortened and rewritten.

(b) Section 4, 5 and 6 have been restructured and rewritten.

Detailed comments:

-p.1072, l.10: The sentence has been corrected: Ozone flux was measured.

-p.1072. l.21. This means the correlation coefficient, which is clarified in the text.

-p.1073. l. 1-2: During the whole measuring period this constant lag value has been used.

-p. 1073, l.20-22: Poor fetch was defined based on Nemitz et al. (2009). During the GRAMINAE integrated field experiment several measuring platforms were settled close to each other at the main site. The exact position of each instrument mast in

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relation to the other masts, mobile laboratories and other obstructions to the fetch was determined and all flux data falling within obstructed sectors were removed from the individual dataset.

-p. 1073, Eq. 2 & p. 1074, Eq. 3: The minus sign is corrected.

-p. 1073, l. 9-10: High-pass filter has been used after McMillen (1988).

-p. 1073, l. 10-12: We have modified the expression two dimensional co-ordinate rotation to double rotation.

-p. 1073, l. 18: The sensible heat flux was corrected for humidity according to the paper by Schotanus et al.(1983).

p. 1075, l. 11: This part of the manuscript has been rewritten.

p. 1076, Eq. 13, and p. 1076, l. 14: Another parameterization is used.

p. 1077, l. 1: We have corrected the sentence.

p.1077, l. 11: Values are corrected. A new figure is also presented.

p. 1077, l. 19: This sentence has been omitted.

p. 1077, l. 21-22: Negative sign is inserted.

p. 1078 (more comments): We agree with all comments. Errors have been corrected. This section has been rewritten.

p. 1079, l. 2: Other papers refer.

p. 1079, l. 9-11: This sentence has been corrected, and the whole section has been extended.

p. 1079, l. 20: As new model calculations have been performed, this part of manuscript has been rewritten.

p. 1080, l. 5: This sentence has been rewritten.

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p. 1080, l. 12-13: Unit (cm s-1) was added.

p. 1080, l. 20: We changed the word to faster.

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