Ozone – Deposition at a Forest Site

a contribution to BIATEX-2

UNIVERSITÄT BAYREUTH

Otto Klemm[1]
and
Alexander Mangold[2]

Bayreuther Institut für Terrestrische Ökosystemforschung

BITÖK

[1]author for correspondence: klemm@bitoek.uni-bayreuth.de [2]now at: Forschungszentrum Jülich, ICG-I: Stratosphäre

INTRODUCTION

The deposition flux of ozone to surfaces such as vegetation, water, and soil is an important issue because **(i)** it is a significant sink for tropospheric ozone, and because **(ii)** the deposited O_3 may act toxic to the vegetation.

The scope of our studies is the quantification of the diurnal and seasonal variations of the deposition flux of O_3 to a forest stand, and to understand the driving processes and parameters.

METHODS

On the one hand, we predict the deposition flux by use of simple BIG - LEAF - model (after Hicks et al., 1987, modified). The model is kept as simple as possible in order to minimize adjustable parameters:

$$F_{O_3} = -c_{O_3} \cdot \frac{1}{R_a + R_b + \left(\frac{1}{R_{cut}} + \frac{1}{R_{stom}}\right)^{-1}}$$

F_{O3}	deposition flux of O_3
c_{O3}	ozone - concentration
R_a	turbulent atmospheric resistance (calculated from turbulence measurements)
R_b	laminar boundary layer resistance (deduced from measurements)
R_{stom}	stomata resistance, from plant physiological model (Falge, 2000)
R_{cut}	surface resistance, parameterized to be 1000 s m^{-1} < R_{cut} < 2000 s m^{-1}, as function of the **measured leaf surface wetness**

On the other hand, the deposition flux was measured with the eddy covariance method.

The vegetation periods of 1999 and 2000 were fully covered.

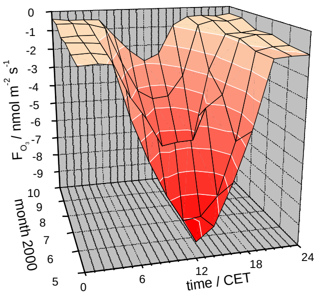
We focus our studies on the ecosystem research site "Waldstein" in the "Fichtelgebirge" mountains in NE Bavaria, at 780 m a.s.l. The forest vegetation consists of Norway Spruce (by 95 %)

The experimantal setup for ozone fluxes is similar to that of Güsten and Heinrich (1996).

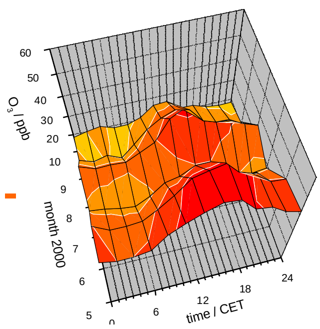
RESULTS

all graphs show medians of hourly data

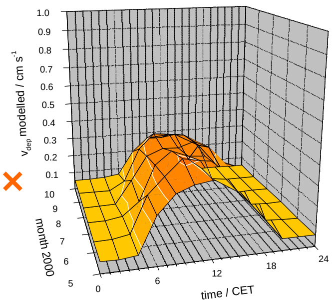
F = - c × v_d



= -



×



Model Results

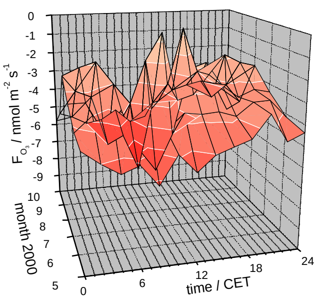
Both c and v_d exhibit clear diurnal and seasonal cycles. This translates to the deposition flux F, with less deposition during the nights due to

- lower O_3 concentrations,
- closure of stomata during the nights

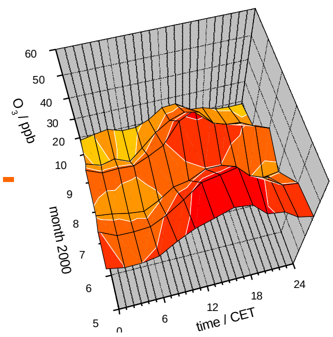
and a seasonal cycle due to

- less O_3 in fall,
- decreasing solar radiation and shorter days in fall.

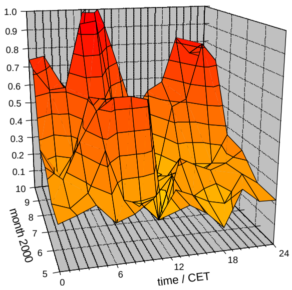
F / - c = v_d



/ -



=



Experimental Results

The measured ozone deposition exhibits no clear diurnal cycle.

The night-time deposition fluxes are particularly high (the quality of these data is high, for further discussion of micrometeorological conditions see Klemm and Mangold, 2001). Later in the year, the measured deposition fluxes are almost always higher than the modelled ones. Despite decreasing O_3 concentrations, the deposition fluxes during fall are as high as those during spring.

CONCLUSIONS

- The measured ozone deposition fluxes are generally larger than the modelled ones (except for the high mid-day model deposition fluxes in spring).
- The measured fluxes hardly show any diurnal cycles
- There is no significant correlation between the ozone deposition and the ozone concentration. This puts the usefulness of concentration–based toxicology concepts such as AOT40 into question.
- Micrometeorological conditions are at least as important as the concentrations of air pollutants in the assessment of potential risks (stronger correlation of measured F with v_d than with c).
- It remains unclear where exactly the ozone deposits to: Which roles play the surfaces such as twigs, and the soil?
- Do soil emissions of NO drive the deposition pattern of O_3? This issue will be addressed within the joint project BEWA 2000.

REFERENCES

Güsten, H. and Heinrich, G.: 1996, On-line measurements of ozone surface fluxes: Part I. Methodology and instrumentation, Atmos. Environ. **30**, 897–909.

Hicks, B.B., Baldocchi, D.D., Meyers, T.P., Hosker, R.P. and Matt, D.R.: 1987, A preliminary mulitple resistance routine for deriving dry deposition velovities from measured quantities, Water, Air, and Soil Pollution **36**, 311-330.

Klemm, O. and Mangold, A.: 2001, Ozone Deposition at a Forest in NE Bavaria. Water, Air, and Soil Pollution Focus 1, 223-232.

Acknowledgements

This study was supported by the German Federal Ministry for Research and Education (BMBF) through grant No. BEO 51-0339476C. Thanks ar due to E. Falge, Th. Foken, J. Gerchau and Th. Wrzesinsky for help and support.

www.bitoek.uni-bayreuth.de