P1.15. ESTIMATION OF OZONE DEPOSITION OVER SUBALPINE FOREST IN NIWOT RIDGE, COLORADO

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1. INTRODUCTION

Air quality monitoring and modelling is important not only to quantify the environmental stress on human health but to understand the role of terrestrial ecosystems in land-atmosphere processes. Tropospheric ozone can influence vulnerability of the ecosystem and its photosynthetic activity. Besides measurements, modelling efforts are of high importance, since availability and spatial/temporal representativeness of field measurements are limited. Therefore, plot level measurements do not provide enough information on ozone concentration and fluxes to give a reliable estimation on ozone effects on ecosystems.

The deposition models are important submodels in chemical transport models. One possible application of deposition models is the investigation and monitoring of the effects of air pollutants on ecosystems. A main part of a deposition model is in general the resistance submodel, which simulates the deposition or exchange of the given species between the atmosphere and surface. The fluxes of trace elements in the model are controlled by the concentration and by the deposition velocity of the elements via parameterization of the aerodynamic, the quasi-laminar boundary layer and the canopy resistance, where this latter term includes stomatal, mesophyll, surface and cuticular resistances.

Deposition models differ in the description and parameterization of energy exchange and surface resistances. The proper choice of parameterization schemes is usually a compromise between application determined requirements and data availability.

The aim of this work is to evaluate different modelling schemes of trace gas deposition, particularly the resistance submodel, regarding practical considerations of large/regional scale modelling.

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2. METHOD AND DATA

As a first step, a validation of three models published in the literature was performed. Basically, the aim is to understand and evaluate the differences between different parameterization schemes, and to find an optimal model for spatial upscaling.

The models used in this study (each are based on the so-called big-leaf concept) are the ZHANG model (Zhang et al., 2003), DEPAC model (Erisman et al., 1994) and the PLATIN model (Grünhage and Haenel, 2008). The first two models are routinely applied in regional chemical transport models, even over large spatial extent (Table 1), therefore it is important to examine the accuracy of their estimations. PLATIN model belongs to the category of models to be used for practical purposes e.g. in agriculture or to establish dose-response functions in ecotoxicology.

The main output of the investigated models is the dry deposition velocity, which is the quotient of the flux (*F*) of the given gas to the surface and the concentration (*c*) of the given gas at a specified reference height (as defined by Chamberlain, 1967):

$$v_{\mathrm{d}} = -\frac{F}{c} = \frac{1}{R_a + R_b + R_c}. \qquad (1)$$

The dry deposition velocity can be calculated as the reciprocal value of the residual resistances: aerodynamic resistance, quasi-laminar boundary layer and canopy resistance, respectively (analogous to Ohm's low in the electricity). R_a is governed by micrometeorological parameters and depends mainly on the local atmospheric turbulence intensities. R_b is governed by diffusivity

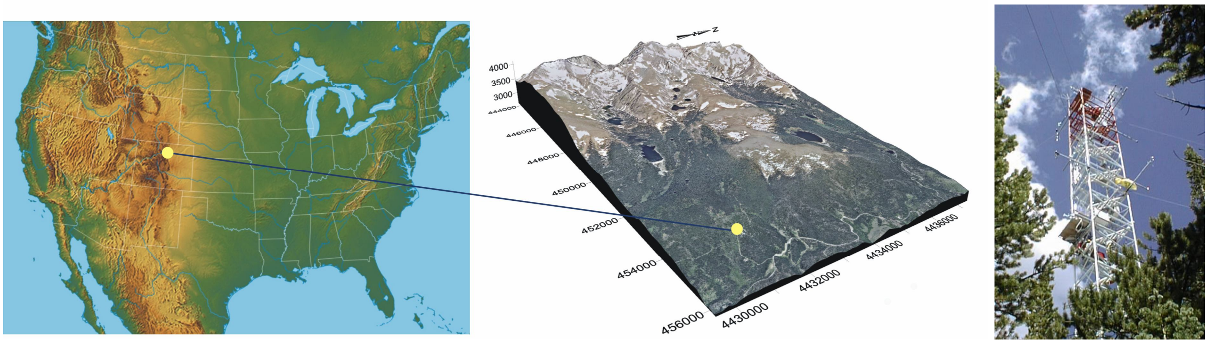


Figure 1: Landscape of the Niwot Ridge site with the Ameriflux tower (40º 02' N, 105º 32' W; 3021 m)

Deposition models	Chemical transport models	Land use categories
ZHANG; Zhang et al., 2003	AURAMS, Smyth at el., 2009	water, ice, inland lake, evergreen needleleaf trees, evergreen broadleaf trees, deciduous needleleaf trees, deciduous broadleaf trees, tropical broadleaf trees, drought deciduous trees, evergreen broadleaf shrubs, deciduous shrubs, thorn shrubs, short grass and forbs, long grass, crops, rice, sugar, maize, cotton, irrigated crops, urban, tundra, swamp, desert, mixed wood forests, transitional forest
DEPAC; Erisman et al., 1994	REMCAL, Stern, 2009 LOTOS-EUROS, Schaap at al., 2008	grass, arable, permanent crops, coniferous forest, deciduous forest, water, urban, short grassy area, desert
PLATIN; Grünhage and Haenel, 2008		grass, forest

Table 1: The investigated deposition models

of the gaseous species and the air viscosity. The formulas for the calculation of the first two terms are similar in different models, but the complexity of parameterization of the latter term varies by a great degree among the models and depends on the model application (Table 2). R_c represents the capacity for a surface to act as a sink for a particular pollutant, and depends on the primary pathways for uptake such as diffusion through leaf stomata, uptake by the leaf cuticular membrane, and deposition to the soil surface.

To be able to validate the results of the deposition models against ground truth, measurements are needed. I used a six months long dataset of Niwot Ridge AmeriFlux site (Colorado, USA) in the Roosevelt National Forest in the Rocky Mountains (Figure 1).

Continuous meteorological and ozone flux measurements above a coniferous forest canopy were carried out during the growing season (May-October) of 2003 (Turnipseed at el., 2009). Quality assurance of measured data included filtering data when friction velocity was less then 0.2 ms^{-1} and/or precipitation was measured.

To explore the real performance of the different resistance schemes of different models, the model resistance schemes were adapted but the meteorological and astronomical parameterizations (e.g. characteristics of moist air and solar radiation) were synchronized using one common scheme and measured meteorological variables were used when it was possible. The only modification was the use of soil moisture (as measured input) instead of water potential to calculate the soil moisture stress during stomatal resistance estimation. Modelled and measured deposition velocities were compared.

3. RESULTS AND CONCLUSIONS

Our results show that deposition models should be used cautiously especially in large scale studies where deposition velocities should be determined over several different ecosystems. None of the investigated models could simulate deposition velocities from flux measurements appropriately. The ZHANG model produced the

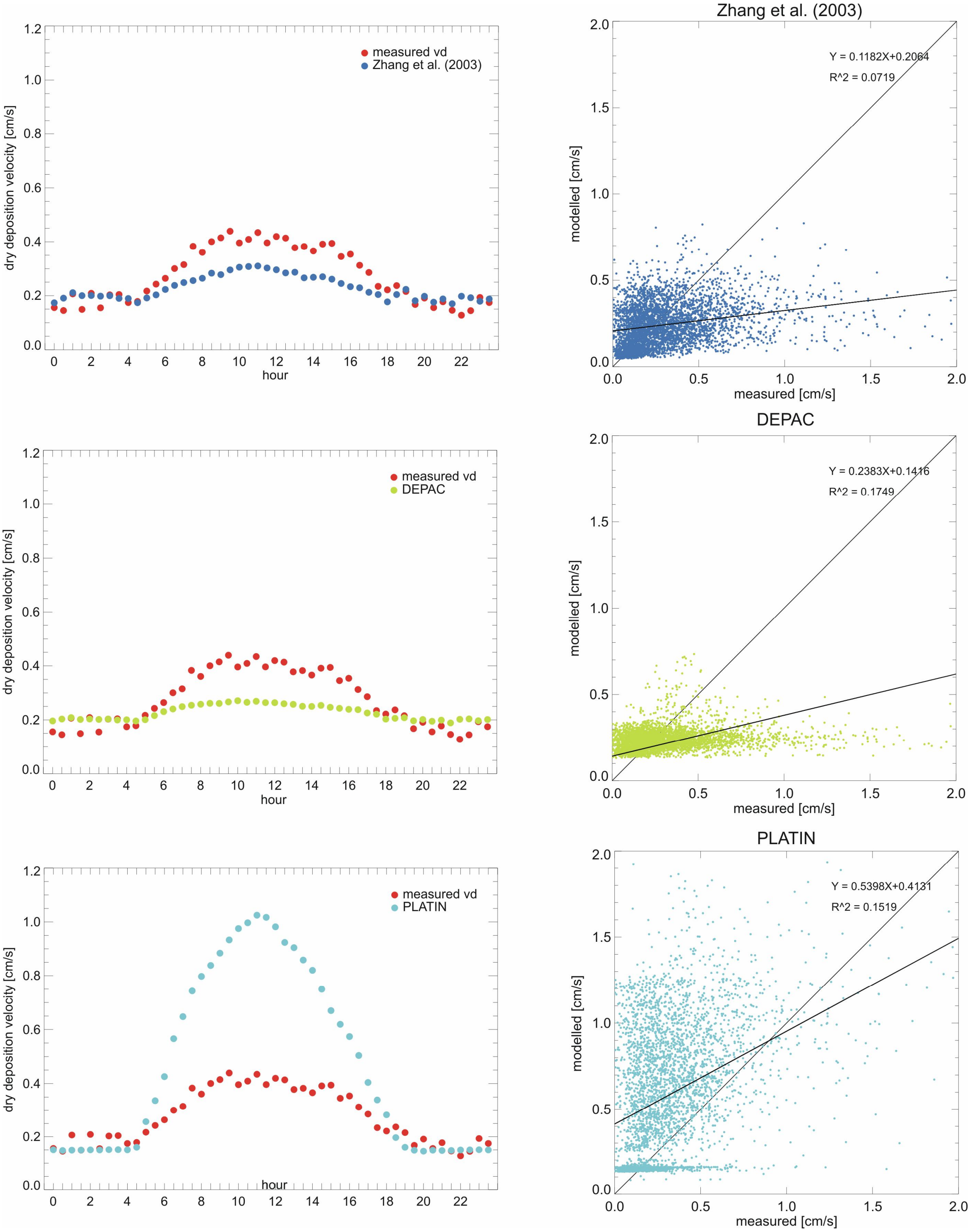
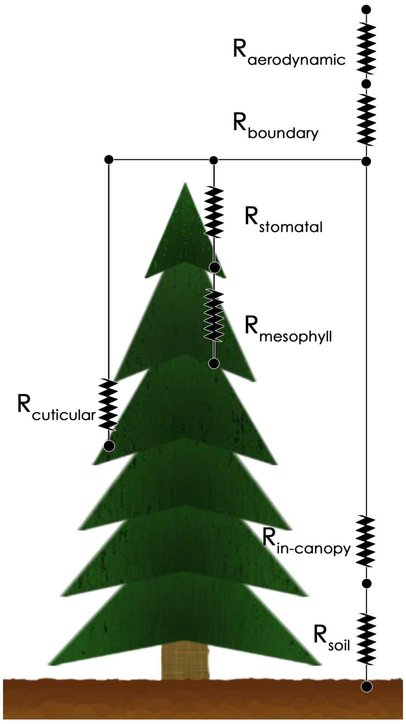


Figure 2: Mean diurnal variation and scatter plot of modelled and measured half-hourly deposition velocities during the measurement period (May-Oct 2003)



Resistance network	Zhang et al., 2003	DEPAC model	PLATIN model
	Wesely and Hicks, 1977		Grünhage and Haenel, 2008
	Hicks et al., 1982		Hicks et al., 1987 Grünhage and Haenel, 2008
	Baldocchi et al., 1987 Zhang et al., 2003	Baldocchi et al., 1987	Jarvis,1976 Grünhage and Haenel, 2008
	Zhang et al., 2003	Wesely, 1989	Wesely, 1989 Grünhage and Haenel, 2008
	Zhang et al., 2003	Erisman et al., 1994	Grünhage and Haenel, 2008
	Van Pul and Jacobs, 1993 Zhang et al., 2003	Van Pul and Jacobs, 1993	$R_{in\text{-}canopy}$ is not exist, R_{ext} is switched parallel with Rsoil Grünhage and Haenel, 2008
	Erisman et al., 1994 Zhang et al., 2003	Erisman et al., 1994	Grünhage and Haenel, 2008

Table 2: Resistance network and parametrizations of resistances

best results in capturing the ozone flux magnitude and dynamics however, one should be aware of the poor correlation between the half-hourly measured and modelled deposition velocities (Figure 2). The PLATIN model significantly overestimates, while the DEPAC model underestimates the measured flux based deposition velocities. According to literature survey and personal communication with developers (in case of the PLATIN model), in spite of their wide acceptance (Brook et al., 1999; Flemming and Stern, 2007), the models have not been calibrated for some important land cover types e.g none of the above models have been calibrated for evergreen forests. Based on the results with cooperation of developers a calibration of PLATIN model will be carried out for coniferous forest.

Our results showed, that the lack of calibration inhibit the use of these models in case of ecosystem types other than they have been calibrated for, and hence, their practicality in large scale studies where models are used over several ecosystems might be questionable. Further investigations are required to optimize the model performance across ecosystems and scales.

4. ACKNOWLEDGEMENTS

The authors would like to thank Prof. Russell Monson and the Niwot Ridge AmeriFlux site for access to their data. We thank DAAD Research Grants for Doctoral Candidates and Young Academics and Scientists enabling the stay of Dalma Szinyei for the 2009/2010 academic year at Freie Universität Berlin, which was used to carry out this research.

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