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Accuracy of cuticular resistance parameterizations in ammonia dry deposition models

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Accurate representation of total reactive nitrogen (N_r) exchange between ecosystems and the atmosphere is a crucial part of modern air quality models. However, bi-directional exchange of ammonia (NH_3), the dominant N_r species in agricultural landscapes, still poses a major source of uncertainty in these models, where especially the treatment of non-stomatal pathways (e.g. exchange with wet leaf surfaces or the ground layer) can be challenging. While complex dynamic leaf surface chemistry models have been shown to successfully reproduce measured ammonia fluxes on the field scale, computational restraints and the lack of necessary input data have so far limited their application in larger scale simulations. A variety of different approaches to modelling dry deposition to leaf surfaces with simplified steady-state parameterizations have therefore arisen in the recent literature. We present a performance assessment of selected cuticular resistance parameterizations by comparing them with ammonia deposition measurements by means of eddy covariance (EC) and the aerodynamic gradient method (AGM) at a number of semi-natural and grassland sites in Europe. First results indicate that using a state-of-the-art uni-directional approach tends to overestimate and using a bi-directional cuticular compensation point approach tends to underestimate cuticular resistance in some cases, consequently leading to systematic errors in the resulting flux estimates. Using the uni-directional model, situations where low ratios of total atmospheric acids to NH_3 concentration occur lead to fairly high minimum cuticular resistances, limiting predicted downward fluxes in conditions usually favouring deposition. On the other hand, the bi-directional model used here features a seasonal cycle of external leaf surface emission potentials that can lead to comparably low effective resistance estimates under warm and wet conditions, when in practice an expected increase in the compensation point due to an equilibrium shift towards ammonia in the gas phase would be expected to limit deposition fluxes. We highlight the respective strengths and shortcomings of both approaches and propose suggestions for the future treatment of this part of the non-stomatal deposition pathway in air quality models.