Response to referees‘ comments – manuscript BG-2022-72 Forest-atmosphere exchange of reactive nitrogen in a low polluted area – Part II: Modeling annual budgets

We thank the anonymous referees for their comments to the manuscript. We rephrased the corresponding lines according to the provided suggestions and clarified the remaining minor points.

Comments of Referee 1 range from R1.1 to R1.21, Comments of Referee 2 range from R2.1 to R2.6. Line numbers in the answers, where new information will be added to the manuscript, refer to the original submitted version. Text marked in red will be deleted, text marked in blue will be implemented in the manuscript.

Response to Referee 1:

General Comment: This manuscript is very interesting and highly relevant in the field of advancing the understanding of dry deposition and flux processes related to Nr. Few minor corrections are needed before publication (corresponding to acceptance with minor revisions).
Response to R1.1: We thank the Reviewer for his/her compliment on this work. We revised the corresponding lines accordingly.

Comment R1.2: line 84: has should be have.
Response to R1.2: Replaced has by have.

Comment R1.3: line 100: reviewing should be review
Response to R1.3: Deleted ing.

Comment R1.4: line 127: hroughfall should be throughfall
Response to R1.4: Added a t.

Comment R1.5: line 152-153: suggest to rephrase as: “…between the atmospheric concentration, Xa, and the compensation point, Xtot, of the trace gas.”
Response to R1.5: We rephrased the sentence according to your suggestion.

Comment R1.6: line 217: include “were” between NH4+ and solely
Response to R1.6: We added were and a p in front of NH_4^+ and NO_3^- to indicate the aerosol (particulate) form.

Comment R1.7: line 255: include “the” between winter and difference
Response to R1.7: Done.

Comment R1.8: line 277: include “be” between partially and verified
Response to R1.8: Done.

Comment R1.9: line 377: remove been at the end of the line
Response to R1.9: Done.

Comment R1.10: line 580: tool should be tools
Response to R1.10: Replaced tool by tools.

Comment R1.11: line 584: include “the” at the beginning of the line (before determined)
Response to R1.11: Done.

Comment R1.12: line 596: include "was" between CBT and based
Response to R1.12: Done.

Comment R1.13: line 683: emission should be emissions
Response to R1.13: Replaced emission by emissions.

Comment R1.14: line 709: happened should be happening
Response to R1.14: Replaced happened by happening.

Comment R1.15: line 710: include "for" between accounted and in
Response to R1.15: Done.

Comment R1.16: line 714: The sentence "Reproducing influences…" does not make sense
Response to R1.16: We agree. We replaced the sentence by Thus, it is not possible to capture the short-term variability of N_r species, which is induced by those parameters, with long-term averages.

Comment R1.17: line 715: include "the" between that and NH3
Response to R1.17: Done.

Comment R1.18 line 718: replace "are probably" with "may be"
Response to R1.18: Done.

Comment R1.19: line 729: include "a" between as and highest
Response to R1.19: Done.

Comment R1.20: line 747: include "the" between to and standard and between resolution and annual
Response to R1.20 Done.

Comment R1.21: In general: check spelling of parameterization throughout, numerous cases of "parametrizations".
Response to R1.21: We replaced parametrizations by parameterizations throughout the manuscript.

Response to Referee 2

General Comment: I have the following (mostly minor) concerns for the authors to consider:
Response to 2.1: Please note our answers to your comments given below.

Comment R2.2: Line 149: Use the title "2.2.1 Bidirectional flux model". Resistance is not bidirectional.
Response to R2.2: We agree. We changed the title accordingly and replaced bidirectional resistance scheme by bidirectional flux model in lines 17 and 796.

Comment R2.3: Line 150: change to "In surface-atmosphere flux exchange models"
Response to R2.3: Added the word flux.

Comment R2.3: Section 3.2, Most statements are qualitative in this section. If a quantitative statement can be presented, it would be easier for readers to catch the major points of the findings. This can be done by simply showing the median and range (or standard deviation) of Vd values from each model (and measurement where applicable) for each chemical species, even though such information is available in Figure 3.
Response to R2.3: In the previous revision phase**,** both Referees suggested to remove most of the quantitative statements to improve readability. Thus, we decided to reduce the level of detail of the descriptions. Since we prefer to keep the current description of the results, but agree to help the reader with an overview of major quantitative results, we added a Table to the supplementary material.

showing medians and lower and upper quartiles of measured and modeled v_d values for each N_r compound. We added a reference to the manuscript (line 324).

Table 1. Medians and lower and upper quartile (LQ and UQ) of measured and modeled deposition velocities for each N_r compound. Values refer to the entire campaign duration.

Method		Deposition velocities [cm s^{-1}]						
		NH_3	NO_2	NO	HNO_3	pNO_3^-	pNH_4^+	ΣN_r
TRANC	UQ							0.73
	Median							**0.34**
	LQ							0.08
DEPAC-1D	UQ	2.4	0.27	0.04	2.3	0.03	0.10	1.0
	Median	**1.3**	**0.06**	**0.0**	**1.6**	**0.01**	**0.05**	**0.52**
	LQ	0.4	0.04	0.0	1.0	0.01	0.03	0.18
LOTOS-EUROS	UQ	2.1	0.24	0.07	2.2	0.32	0.19	0.71
	Median	**1.0**	**0.12**	**0.04**	**1.6**	**0.15**	**0.11**	**0.42**
	LQ	0.4	0.05	0.01	1.2	0.08	0.05	0.22

Comment R2.4: Section 3, Try to use more quantitative statements when comparing fluxes between different models (and measurements).
Response to R2.4: Please note our response to R2.3. We added a table to the supplementary material showing ΣN_r flux averages of TRANC, LOTOS-EUROS, and DEPAC-1D for each season and the entire campaign duration. A reference to the table was added to line 415.

Table 2. Median fluxes of TRANC, DEPAC-1D and LOTOS-EUROS ng N m^{-2} s^{-1} in for different periods

Time	TRANC [ng N m^{-2} s^{-1}]	DEPAC-1D [ng N m^{-2} s^{-1}]	LOTOS-EUROS [ng N m^{-2} s^{-1}]
Winter	7.5	4.7	12.5
Spring	10.8	18.3	22.5
Summer	9.3	21.9	21.1
Autumn	9.5	20.3	17.5
Entire campaign	9.3	15.4	19.2

Comment R2.5: Section 4: When splitting Results and Discussion into two separate sections, I would expect "Results" section to present all the comparison results, while "Discussion" section to discuss the causes of the comparison results. However, I see much more comparison results than discussions of the causes in Section 4.
Response to R2.5: In the discussion section, key aspects of the comparison results were written out to introduce the reader into certain aspects of the discussion. Please note that an in-depth discussion of the causes is difficult since the exact composition of the measured ΣN_r flux is not known. However, we noticed that some sentences of the discussion can be removed (lines 484-487, 623-625, and 634-635), and the discussion on NO_2 and HNO_3 can be slightly extended. Thus, we added these sentences to the beginning of line 530:
The observed temporal pattern in v_d of NO_2 is related to the stomatal uptake, which is close to zero in winter and highest in summer. The slight difference in deposition velocities of NO_2 were caused by higher measured concentrations of NO_x (see Fig. S2).
At the end of line 567, we added the following information:
Issues in the description of turbulence-controlled deposition had also an effect on HNO_3 since its R_c is set to a relatively low constant value. Thus, LOTOS-EUROS deposition fluxes of HNO_3 were substantially higher in winter than deposition fluxes of DEPAC-1D. During summer, differences in deposition velocities were related to higher measured concentrations of HNO_3 (see Fig. S2).

Comment R2.6: Line 773, I am not sure the exact causes for the high deposition velocities of pNH4

+ , pNO3 – from LOTOS-EUROS. I just want to caution that: Vd for these particle species should be integrated over a size distribution (e.g., with assumed lognormal size distribution which needs a mass mean diameter, a geometric standard deviation, and a size-cut range, see a description of these parameters in Wang et al., 2014, JAMES, 6, 1301-1310), not using a single size Vd, the latter can be very different from the former. Alternatively, a bulk Vd version of the model can be used (Zhang and He, 2014, ACP, 14, 3729-3737).

Response to R2.6: Yes, LOTOS-EUROS did an integration over a fixed, i.e., neglecting influence of humidity, size distribution using a lognormal size distribution which needs a mass mean diameter, a geometric standard deviation, and a size-cut range to calculate v_d for particles. Thus, we assume that uncertainties in the parameterization of stability regarding snow cover are responsible for the large deposition velocities of LOTOS-EUROS. We added the highlighted information to line 773.