

Table S1 Equations of the direct processes calculating NH₃ volatilization from upland soils in the original and modified CNMM-DNDC model.

Equations	Description	
<i>Original CNMM-DNDC model</i>		
Urea hydrolysis		
$d[\text{NH}_4^+]_j/dt = -d[\text{urea}]_j/dt$	Urea hydrolysis rate	Eq. 1
$= f_T f_{\text{SOC}} [\text{urea}]_j$		
$f_T = 0.0364e^{0.0805T_{\text{soil}}}$	Effect of soil temperature on urea hydrolysis	Eq. 2
$f_{\text{SOC}} = 0.01[\text{SOC}]_j^{-1}$	Effect of soil temperature on urea hydrolysis	Eq. 3
ABC decomposition		
$f_{\text{ABC_dec}} = f_{\text{pH}} f_{\text{dp}}$	ABC decomposition rate	Eq. 4
$f_{\text{pH}} = 0.1\text{pH} - 0.5$	Effect of soil pH on ABC decomposition	Eq. 5
$f_{\text{dp}} = 6.0 \times 10^{-3.6735j/q-0.7551}$	Effect of soil depth on ABC decomposition	Eq. 6
$\text{NH}_3\text{_{flux}(j)} = f_{\text{ABC_dec}} [\text{NH}_4\text{HCO}_3]_j$	NH ₃ volatilization from ABC decomposition	Eq. 7
NH₃ volatilization		
$\text{Flux}(\text{NH}_3)_{\text{upland}(j)} = 0.25 f_{\text{wind}} f_{\text{depth}} f_{\text{temp}} [\text{NH}_3(\text{l})]_j$	NH ₃ flux from uplands	Eq. 8
$f_{\text{wind}} = 1.5 S_{\text{wind}} / (1.0 + S_{\text{wind}})$	Effect of wind speed on NH ₃ volatilization	Eq. 9
$f_{\text{depth}} = (\frac{d_s}{d_1} - j) / (\frac{d_s}{d_1})$	Effect of soil depth on NH ₃ volatilization	Eq. 10
$f_{\text{temp}} = T_{\text{soil}} / (50 + T_{\text{soil}})$	Effect of soil temperature on NH ₃ volatilization	Eq. 11
<i>Modified CNMM-DNDC model</i>		
Urea hydrolysis		
$d[\text{NH}_4^+]_j/dt = -d[\text{urea}]_j/dt$	Urea hydrolysis rate	Eq. 12
$= f_T f_{\text{SOC}} f_{\text{SM}} [\text{urea}]_j$		
$f_T = 0.45e^{0.025T_{\text{soil}}}$	Effect of soil temperature on urea hydrolysis	Eq. 13

$$f_{SM} = \text{WFPS}/\text{PORE}$$

Effect of soil moisture on urea hydrolysis Eq. 14

$$f_{SOC} = 0.01[\text{SOC}]_j^{-1}$$

Effect of soil temperature on urea hydrolysis Eq. 15

ABC decomposition

$$f_{ABC_dec} = f_{pH} f_{dp} f_{T_s_ABC}$$

ABC decomposition rate Eq. 16

$$f_{pH} = 0.1\text{pH} - 0.5$$

Effect of soil pH on ABC decomposition Eq. 17

$$f_{dp} = 6.0 \times 10^{-3.6735j/q-0.7551}$$

Effect of soil depth on ABC decomposition Eq. 18

$$f_{T_s_ABC} = T_{soil}/(30 + T_{soil})$$

Effect of soil temperature on ABC decomposition Eq. 19

$$\text{NH}_3_flux(j) = f_{ABC_dec} [\text{NH}_4\text{HCO}_3]_j$$

NH₃ volatilization from ABC decomposition Eq. 20

NH₃ volatilization

$$\text{Flux}(\text{NH}_3)_{\text{upland}(j)}$$

NH₃ flux from uplands Eq. 21

$$= 3.6 f_{wind} f_{depth} f_{temp} f_{canopy} f_{clay} f_{water} f_{rain} [\text{NH}_3(l)]_j$$

$$f_{wind} = 0.1 + 1.5 S_{wind}/(1 + S_{wind})$$

Effect of wind speed on NH₃ volatilization Eq. 22

$$f_{depth} = 0.5^{d_{soil}/0.03}$$

Effect of soil depth on NH₃ volatilization Eq. 23

$$f_{temp} = 0.1 + 2.0 T_{soil}/(45 + T_{soil})$$

Effect of soil temperature on NH₃ volatilization Eq. 24

$$f_{canopy} = 0.4e^{-0.15lai} + 0.6$$

Effect of dry canopy on NH₃ volatilization Eq. 25

$$f_{clay} = e^{-0.06cl}$$

Effect of soil clay content on NH₃ volatilization Eq. 26

$$f_{water} = 0.45e^{-10\text{WFPS}_j} + 0.55$$

Effect of soil moisture on NH₃ volatilization Eq. 27

$$f_{rain} = 0.65e^{-1.0laiP} + 0.35$$

Effect of rain wetting canopy on NH₃ volatilization Eq. 28