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Supplement of

Soil concentrations and soil–atmosphere exchange of alkylamines in a boreal Scots pine forest

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Supplement A: Amine concentrations in field samples

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Figure S2. Sensitivities of soil, quasi-laminar flow and aerodynamic resistances to environmental variables used in the resistance analogy calculations.

Supplement A: Modeling the mean flow field, momentum flux and turbulent diffusivity with the canopy

Table S1. Alkylamine concentrations in soil fungal biomass, humus soil and mineral soil collected from a Scots pine forest.

	Diethylamine	2-amino-1-butanol	DL-2-aminobutyric acid
	µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW
Soil fungal biomass	2.9	9.7	10
Humus soil	0.3	3.7	0.7
Mineral soil	>0.01	>0.01	>0.01

Supplement A: Amine concentrations in field samples

Much of this material is presented in Launiainen et al. (2013, 2015); however, the salient features are reviewed for completeness. In a stationary and planar-homogeneous flow at high Reynolds number in near-neutral conditions, the mean momentum budget within the canopy reduces to

$$\frac{\partial \overline{u'w'}}{\partial z} = -C_d a(z) U^2, \tag{B1}$$

where C_d is the foliage drag coefficient (here 0.15) usually between 0.1-0.3 (Katul et al., 2004), U the mean horizontal velocity and $a(z)$ the local leaf-area density ($\mathrm{m^2\,m^{-3}}$). Using the first-order closure principles the momentum flux $\overline{u'w'}$ is written as

$$\overline{u'w'} = -K_m \frac{\partial U}{\partial z}. \tag{B2}$$

Inserting equation B2 into equation B1 results in a homogeneous second-order nonlinear ordinary differential equation

$$K_m \frac{\partial^2 U}{\partial z^2} + \frac{\partial K_m}{\partial z}\frac{\partial U}{\partial z} - C_d a(z) U^2 = 0, \tag{B3}$$

where the eddy diffusivity for momentum (K_m) is related to local gradient of U through the mixing length l as

$$K_m = l^2 \left|\frac{\partial U}{\partial z}\right|. \tag{B4}$$

The effective mixing length (l) is given as

$$l = \begin{cases} k_v z, & z < \alpha' h / k_v \\ \alpha' h, & \alpha' h / k_v \le z < h \\ k_v (z - d), & z \ge h \end{cases}, \tag{B5}$$

where d is the zero-plane displacement height (determined as the centroid of drag force by the iterative solution of B3), $k_v = 0.41$ is the von Karman constant and h the canopy height (15 m). The parameter $\alpha' = (d - h)\, k_v/h$ ensures continuity (but not smoothness) in the mixing length. The eq. B2 can be solved when the leaf-area density profile and two boundary conditions on the mean velocity are provided. For a, we use estimated leaf-area density profile with one-sided LAI = 3.5 $m^2\,m^{-2}$ for the Hyytiälä SMEAR II –site (Launiainen et al., 2013). The upper boundary condition is set as the mean normalized horizontal velocity at z/h ~1.5 ($U/u^* = 5.06$) representing near-neutral conditions at the Hyytiälä site (Launiainen et al. 2007). A no-slip boundary condition was assumed at the ground.

Figure S1 shows the leaf-area density and resulting u_*-normalized U, $\overline{u'w'}$, K_m and l profiles. The momentary values of U, $\overline{u'w'}$ and K_m for each measurement period are then derived by multiplying the normalized profiles by the measured above-canopy u_*. For calculating r_a (eq. 10) the scalar eddy diffusivity (K_s) was taken equal to K_m, i.e. assigning the turbulent Schmidt number to unity. The near-ground friction velocity $u_{*g} = \overline{u'w'}^{1/2}$ for computing soil boundary layer resistance (eq. 9) is taken from the first computational node (z = 0.23 m) above the soil surface.

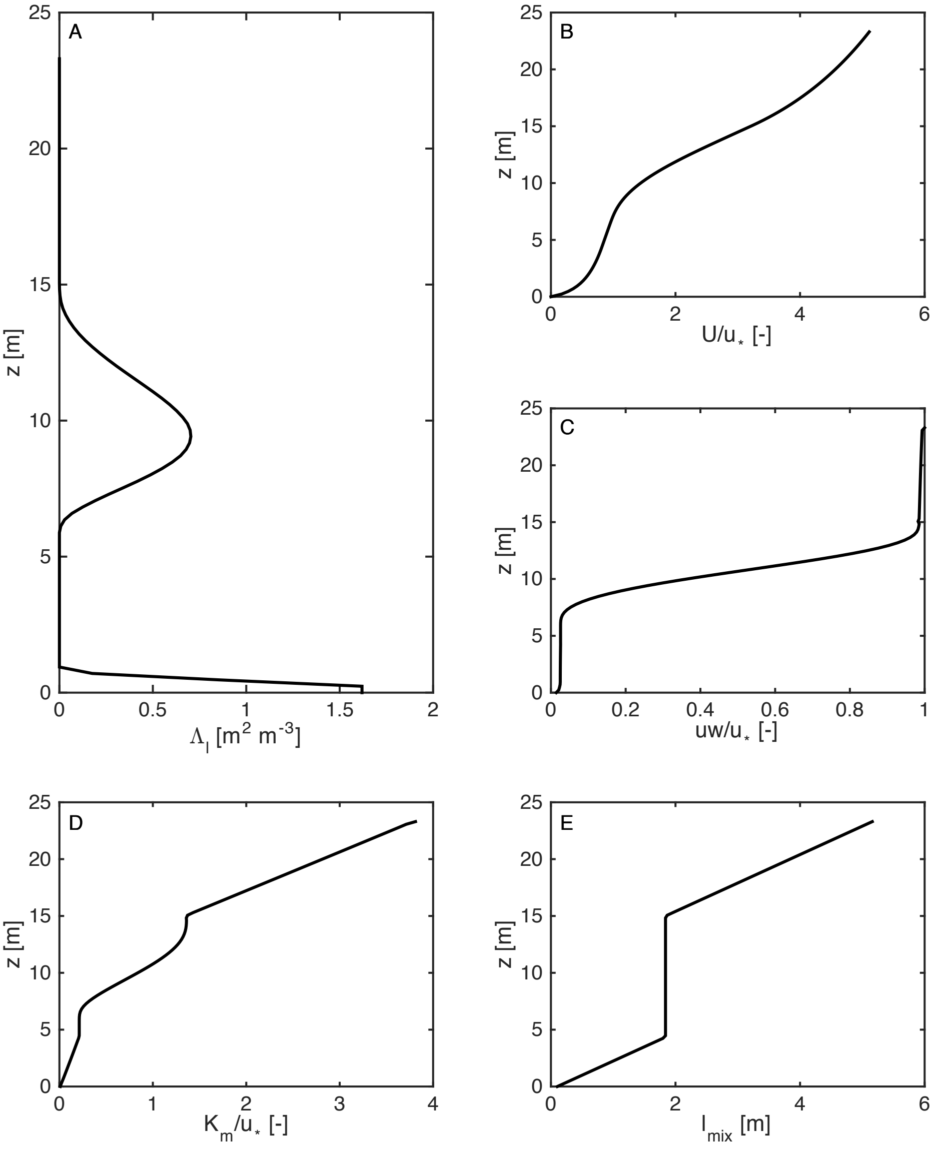

Figure S1: The leaf-area density (Λ_l, panel A) and resulting friction velocity (u_*) normalized mean horizontal velocity (U, panel B), momentum flux ($\overline{u'w'}$, panel C), eddy diffusivity of momentum (K_m, panel D), and effective mixing length (l_{mix}, panel E) profiles. In the studied forest, the canopy top is at 15 m.

Supplement C: Pure fungal cultured strains and their amine concentrations

Table S2. Fungal strains used in pure cultures and their accession numbers, alkylamine concentration (µg g^{-1} FW), fresh and dry weights (g) of samples and dry mass percentages.

	Code	Media	Identified name (Blast)	Accession number	Dimethylamine	Diethylamine	Methylamine	Ethanolamine	sec-butylamine	Dibutylamine	Amine sum			
					µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW	µg g^{-1} FW	g FW	g DW	Dry mass %
Ectomycorrhiza	JH 5	LN-AS	*Tomentellopsis* sp.	LK052757	72.1	1.45	2.89	1.02	-	1.06	78.5	0.24	0.07	28.7
	JH 7	LN-AS	mycorrhizal basidiomycote	AM905083	152	2.34	6.45	2.09	-	1.75	164	0.12	0.11	85.9
	JH 33	LN-AS	*Piloderma olivaceum*	AM910819	289	7.32	13.1	6.95	-	3.63	320	0.03	0.01	20.5
	JH 48	LN-AS	*Suillus variegatus*	LK052771	111	2.55	5.57	2.93	3.45	1.07	127	0.11	0.07	67.8
	JH 151	LN-AS	*Suillus variegatus*		35.2	0.88	1.56	1.97	-	0.42	40.0	0.29	0.11	37.9
	JH 101	LN-AS	*Cenococcum geophilum*	AM910820	133	2.62	6.07	3.18	6.27	1.47	152	0.10	0.09	87.4
	JH 131	LN-AS	*Rhizopogon roseolus*	LK052810	17.2	0.32	0.73	0.31	-	0.15	18.7	0.79	0.24	30.5
Ericoid mycorrhiza	JH 82	LN-AS	*Oidiodendron maius*	LK052786	116	2.52	4.90	2.34	-	1.34	127	0.10	0.05	48.0
	JH 119	LN-AS	*Oidiodendron pilicola*	LK052804	54.8	1.01	2.41	1.08	0.50	0.53	60.3	0.25	0.04	17.8
	JH 134	LN-AS	*Rhizoscyphus ericae* aggr.	LK052811	69.8	2.30	2.99	2.52	-	1.12	78.7	0.11	0.05	43.3
Endophytes	JH 1	LN-AS	*Phialocephala fortinii*	AM905081	8.05	0.17	0.42	0.18	1.05	0.14	10.0	2.30	0.36	15.5
	JH 8	LN-AS	*Phialocephala fortinii*	AM905084	3.58	0.14	0.17	0.08	0.14	0.19	4.30	5.26	0.67	12.8
	JH 121	LN-AS	*Phialocephala fortinii*	LK052805	12.3	0.31	0.56	0.30	1.04	0.15	14.7	0.84	0.15	18.3
	JH 161	LN-AS	*Phialocephala fortinii*		4.20	0.12	0.22	0.21	1.13	0.07	5.94	1.93	0.29	15.1
	JH 23	LN-AS	*Meliniomyces variabilis*	AM905085	48.8	0.72	2.00	0.90	1.56	0.37	54.4	0.38	0.22	57.4
	JH 31	LN-AS	*Meliniomyces variabilis*	AM905088	12.3	0.15	0.60	0.22	0.33	0.08	13.7	1.63	0.93	56.8
	JH 110	LN-AS	*Pochonia bulbillosa*	LK052798	86.4	1.80	3.80	1.90	4.79	0.87	100	0.14	0.12	86.7
Decay fungi	Cdry	LN-AS	*Collybia dryophila*		680	12.7	30.5	12.3	-	6.49	742	0.02	0.00	14.1
	JH 93	LN-AS	*Cladophialophora* sp.		37.1	0.90	1.78	1.01	7.85	0.41	49.1	0.32	0.06	17.6
Control agar media					4.25	0.13	0.19	0.12	-	0.06	4.75	1.93	0.29	15.1

Table S3. Alkyl amine concentrations (μg g^{-1} FW) of ecological fungal functional groups. The concentration is mean (±standard deviation) of strains in each fungal functional group used in pure fungal cultures.

		Dimethylamine	Diethylamine	Methylamine	Ethanolamine	sec-Butylamine	Dibutylamine
	n	μg g^{-1} FW	μg g^{-1} FW	μg g^{-1} FW	μg g^{-1} FW	μg g^{-1} FW	μg g^{-1} FW
Ectomycorrhiza	7	116 (±34)	2.50 (±0.87)	5.20 (±1.57)	2.63 (±0.81)	1.39 (±0.95)	1.36 (±0.43)
Ericoid mycorrhiza	3	80.1 (±18.3)	1.94 (±0.47)	3.43 (±0.75)	1.98 (±0.45)	0.17 (±0.17)	0.10 (±0.24)
Endophyta	7	25.1 (±11.8)	0.49 (±0.23)	1.11 (±0.51)	0.54 (±0.25)	1.44 (±0.59)	0.27 (±0.11)
Decay fungi	2	359 (±322)	6.79 (±5.89)	16.1 (±14.4)	6.65 (±5.64)	3.93 (±3.93)	3.45 (±3.04)
Control agar media		4.25	0.13	0.19	0.12	n.d.	0.06

Supplement D: Sensitivities of resistances to environmental variables

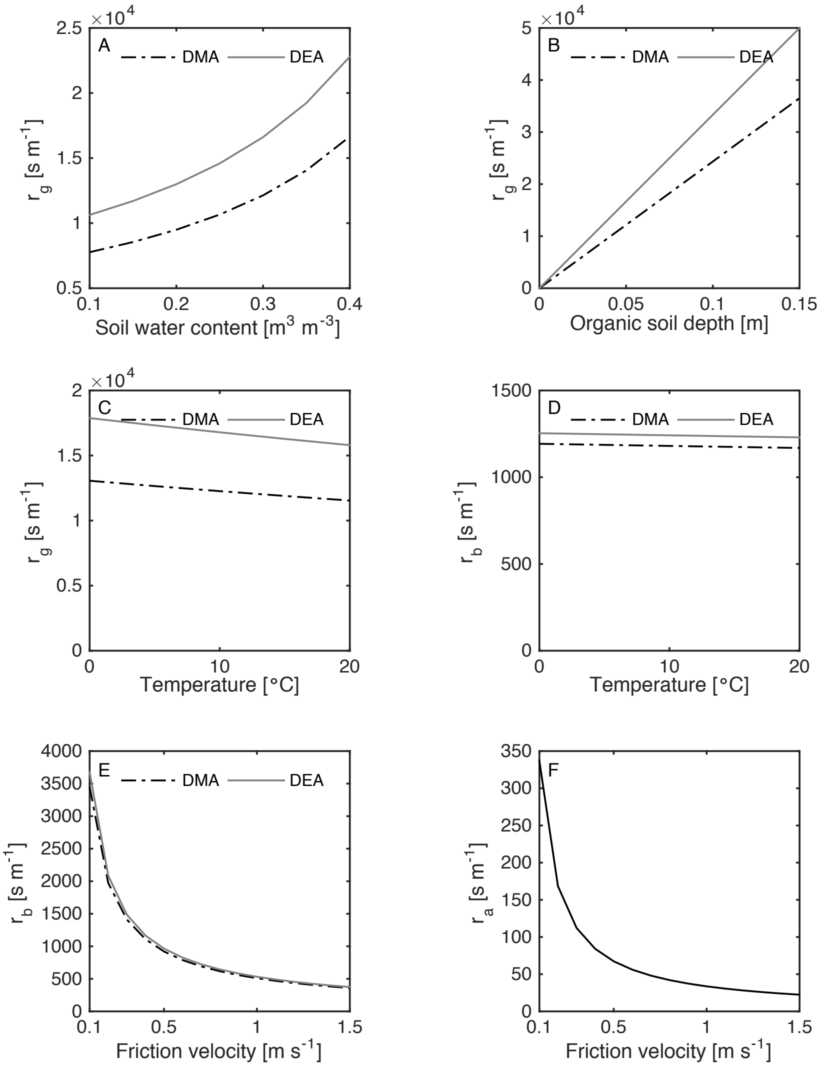

Figure S2. Sensitivities of soil resistances (r_s) to soil water content, soil depth and temperature are shown in panels A, B, and C, respectively. Sensitivity of quasi-laminar resistance (r_b) to temperature is shown in panel D and to friction velocity in panel E. Sensitivity of aerodynamic resistance (r_a) to friction velocity is in panel F.