Supplement of

Similar freezing spectra of particles on plant canopies as in air at a high-altitude site

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Table S1: Data acquired from trees sampled in Gempen (FS: *F. sylvatica*, JR: *J. regia*, PA: *P. avium*, TP: *T. platyphyllos*): leaf colour as NCS code, differential INP concentration k(T), spectral type (mon: monotonous increase, brackets for spectra with insignificant peaks). Duplicate measurements of leaf C and N displayed in separate rows.

dd/mm/yyyy	no	tree ID	NCS code	$k(T)$ (cm^{-2} K^{-1}) -2.5	-3.5	-4.5	-5.5	-6.5	-7.5	-8.5	-9.5	INP$_{-10}$ (cm^{-2})	spectral type	LMA (g m^{-2})	δ^{13}C (‰)	N (mg (g dry weight)$^{-1}$)	C:N atomic ratio
09/08/2023	1	FS1	4050 G40Y	0.00	0.00	0.00	0.27	0.54	1.22	2.13	3.51	7.7	mon	84.6	-30.7	29.1	19.4
	2	FS2	3050 G30Y	0.00	0.00	0.00	0.98	2.00	6.28	10.32	16.79	36.4	mon	36.5	-31.9	19.2	28.6
	3	JR1	3050 G30Y	0.00	0.00	0.00	0.00	7.97	5.23	3.78	2.13	19.1	>-7.5	31.4	-33.4	33.1	14.1
	4	JR2	5030 G30Y	0.00	0.00	0.00	0.04	0.29	0.21	0.55	2.39	3.5	(>-7.5)	74.9	-29.8	38.5	14.2
	5	PA1	3050 G30Y	0.00	0.00	0.00	0.03	0.33	0.65	1.43	1.60	4.0	mon	75.7	-29.3	24.8	22.4
	6	PA2	4050 G40Y	0.00	0.00	0.00	0.02	0.09	0.30	0.64	0.71	1.8	mon	89.2	-29.1	19.6	28.0
	6	PA2													-29.3	20.2	27.3
	7	TP1	4050 G40Y	0.00	0.00	0.00	0.04	0.05	0.11	0.30	0.22	0.7	(-8.5)	49.4	-28.5	36.4	15.1
	8	TP2	4050 G40Y	0.00	0.00	0.02	0.03	0.13	0.36	0.42	0.76	1.7	mon	49.7	-28.5	33.9	16.3
22/08/2023	9	FS1	3560 G30Y	0.00	0.00	0.02	0.06	2.04	3.74	4.49	5.32	15.7	mon	79.0	-30.7	21.0	27.1
	10	FS2	3560 G30Y	0.00	0.00	0.06	0.15	1.60	3.82	11.81	18.42	35.9	mon	30.0	-33.6	26.8	20.8
	11	JR1	6030 G30Y	0.00	0.00	0.00	0.09	1.43	2.37	2.33	3.05	9.3	-7.5	31.7	-33.8	35.4	14.3
	12	JR2	5030 G30Y	0.00	0.00	0.00	0.03	0.31	0.69	0.88	2.05	4.0	mon	47.7	-32.2	33.3	16.8
	13	PA1	5040 G40Y	0.00	0.00	0.00	0.41	2.49	1.29	0.00	0.51	4.7	>-7.5	71.5	-29.6	22.0	24.8
	14	PA2	4550 G40Y	0.00	0.00	0.00	0.02	0.11	0.65	1.20	0.70	2.7	-8.5	73.4	-29.5	21.8	25.9
	15	TP1	4550 G40Y	0.00	0.00	0.00	0.00	0.08	0.40	0.68	0.31	1.5	-8.5	46.9	-28.1	32.5	17.0
	16	TP2	4050 G40Y	0.00	0.00	0.00	0.46	2.75	4.98	13.74	3.68	25.6	-8.5	33.2	-29.9	27.9	18.2
	16	TP2													-30.2	30.4	16.9
12/09/2023	17	FS1	4550 G50Y	0.00	0.00	0.00	0.04	0.16	1.07	1.83	4.90	8.0	mon	82.2	-29.7	24.7	23.1
	18	FS2	4050 G40Y	0.00	0.00	0.04	0.82	2.59	22.70	18.84	25.28	70.3	-7.5	29.7	-34.0	23.2	23.5
	19	JR1	4550 G30Y	0.02	0.03	0.09	0.34	1.20	1.97	4.15	7.47	15.3	mon	26.8	-34.2	33.1	14.9
	19	JR1													-34.2	33.3	14.7
	20	JR2	5540 G30Y	0.00	0.00	0.10	0.02	0.21	1.33	1.69	4.80	8.2	>-7.5	53.7	-30.0	27.8	18.7
	21	PA1	5450 G30Y	0.00	0.00	0.00	0.12	0.28	0.49	3.06	6.84	10.8	mon	69.7	-29.8	20.2	27.0
	22	PA2	4050 G40Y	0.00	0.00	0.00	0.12	0.18	0.55	0.55	1.76	3.1	(-7.5)	85.1	-29.3	15.1	38.3
	23	TP1	5540 G40Y	0.00	0.00	0.00	0.02	0.37	0.90	0.81	1.42	3.5	(-7.5)	48.0	-29.2	31.1	17.1
	24	TP2	4050 G40Y	0.00	0.00	0.02	0.47	2.14	7.91	2.29	9.02	21.8	-7.5	40.5	-30.3	28.8	17.8

| dd/mm/yyyy | no | tree ID | NCS code | $k(T)$ $(cm^{-2}\,K^{-1})$ | | | | | | | | INP_{-10} (cm^{-2}) | spectral type | LMA $(g\,m^{-2})$ | $\delta^{13}C$ (‰) | N $(mg\,(g$ dry weight$)^{-1})$ | C:N atomic ratio |
				-2.5	-3.5	-4.5	-5.5	-6.5	-7.5	-8.5	-9.5						
26/09/2023	25	FS1	6030 G70Y	0.00	0.00	0.04	0.10	2.68	2.80	20.52	69.09	95.2	mon	65.1	-30.2	21.0	26.0
	25	FS1													-29.9	20.2	26.7
	26	FS2	5040 G40Y	0.00	0.00	0.02	0.66	4.71	7.56	32.68	61.09	106.6	mon	40.3	-33.8	22.6	24.1
	27	JR1	5040 G30Y	0.09	1.34	2.24	0.92	0.97	9.65	22.59	34.77	72.6	>-7.5	62.0	-31.0	30.0	18.4
	28	JR2	5040 G30Y	0.00	0.00	0.02	0.71	2.61	1.88	2.26	4.89	12.4	>-7.5	28.6	-33.8	31.7	15.9
	29	PA1	5040 G40Y	0.00	0.07	0.13	0.14	0.67	2.19	2.24	3.12	8.6	mon	66.5	-30.4	22.5	23.8
	30	PA2	0560 Y	0.00	0.00	0.02	0.04	0.26	1.96	2.66	3.46	8.4	mon	76.3	-30.8	10.0	55.3
	31	TP1	5040 G50Y	0.00	0.00	0.00	0.00	0.08	0.10	0.35	0.47	1.0	mon	54.5	-28.3	24.7	22.7
	32	TP2	5040 G40Y	0.00	0.00	0.03	0.71	1.71	3.85	3.48	10.05	19.8	(-7.5)	40.0	-30.1	26.6	19.6
03/10/2023	33	FS1	6030 G90Y	0.00	0.00	0.00	0.05	1.08	7.99	6.22	13.37	28.7	-7.5	72.7	-29.8	20.1	27.2
	34	FS2	3050 Y20R	0.00	0.00	0.35	5.98	6.55	9.31	13.71	36.78	72.7	mon	24.3	-34.7	8.7	61.5
	35	JR1	5040 G40Y	0.00	0.06	0.06	1.12	5.12	8.19	6.66	12.48	33.7	-7.5	31.7	-34.3	30.9	16.5
	36	JR2	2060 Y10R	0.02	0.10	0.36	0.35	0.53	1.91	8.26	39.60	51.1	(>-7.5)	44.4	-31.6	10.0	53.2
	37	PA1	4050 G40Y	0.02	1.03	1.32	1.41	1.82	4.10	10.33	8.49	28.5	-8.5	80.2	-29.9	17.6	30.8
	38	PA2	1050 Y80R	0.00	0.00	0.04	0.15	0.75	1.81	2.48	3.67	8.9	mon	73.4	-28.9	9.7	57.8
	39	TP1	4040 G50Y	0.00	0.00	0.00	0.14	2.70	3.00	2.06	2.68	10.6	-7.5	52.7	-28.9	21.6	25.3
	40	TP2	2060 G90Y	0.00	0.08	0.12	3.67	3.86	3.52	3.27	4.01	18.5	(>-7.5)	35.1	-29.5	12.2	42.3
17/10/2023	41	FS1	5040 G50Y	0.00	0.00	0.02	0.02	0.23	1.28	2.85	5.64	10.0	mon	92.1	-30.4	15.4	31.4
	42	FS2	4050 G40Y	0.00	0.00	0.06	3.01	6.25	10.37	11.27	17.47	48.4	mon	31.7	-34.0	20.7	25.9
	43	JR1	4550 G30Y	0.00	0.00	0.00	0.13	0.73	2.74	4.26	6.02	13.9	mon	24.4	-34.6	26.1	18.9
	44	JR2	5020 Y30R	0.00	0.07	0.13	0.10	0.33	2.97	13.65	11.02	28.3	-8.5	53.7	-30.9	9.7	57.2
	45	PA1	4050 G40Y	0.00	0.00	0.00	0.09	1.20	7.59	10.68	9.74	29.3	-8.5	81.9	-30.6	19.6	27.2
	46	PA2	1060 Y10R	0.00	0.00	0.12	0.31	0.86	3.43	5.67	4.72	15.1	(-8.5)	74.5	-29.9	9.9	56.1
	46	PA2													-29.3	11.0	51.4
	47	TP1	4040 Y30R	0.00	0.00	0.00	0.01	0.23	0.86	1.75	2.20	5.1	mon	40.4	-28.3	10.8	49.3
	48	TP2	2050 Y10R	0.00	0.00	0.00	0.59	2.71	10.45	6.22	6.06	26.0	-7.5	38.9	-29.6	9.2	56.8
30/10/2023	49	FS1	1070 Y10R	0.00	0.00	0.07	0.15	0.52	3.05	6.00	36.43	46.2	mon	85.2	-31.5	11.1	50.9
	50	FS2	4050 Y40R	0.00	0.02	0.51	2.36	3.05	14.79	23.12	32.01	75.9	mon	28.6	-34.6	7.1	74.4
	51	JR1	1060 Y	0.00	0.00	0.04	0.12	0.50	1.21	2.53	5.21	9.6	mon	20.7	-34.4	10.2	47.2
	52	JR2	5030 Y20R	0.03	1.77	1.84	2.05	1.70	8.74	29.52	41.16	86.8	(>-7.5)	53.4	-30.3	9.9	55.1
	52	JR2													-30.0	9.6	56.8
	53	PA1	0570 Y10R	0.00	0.02	1.01	4.29	9.32	9.71	9.68	13.40	47.4	(-7.5)	78.5	-30.6	12.0	44.7
	54	PA2	1040 Y60R	0.00	0.17	0.25	0.27	1.19	6.26	22.21	19.70	50.1	-8.5	78.0	-28.6	9.3	60.0
	55	TP1	3040 Y30R	0.00	0.12	0.10	0.15	0.67	1.46	3.07	1.43	7.0	-8.5	46.8	-29.0	10.8	49.9
	56	TP2	2040 Y	0.00	0.00	0.30	2.88	4.94	6.00	2.98	4.81	21.9	-7.5	36.0	-30.6	13.5	39.0
15/11/2023	57	FS1	6030 Y50R	0.00	0.00	0.02	0.02	0.16	1.00	2.37	7.59	11.1	mon	57.6	-31.6	9.5	59.9
	58	FS2	5040 Y50R	0.00	0.02	0.33	2.67	4.58	7.73	10.80	16.22	42.3	mon	34.6	-34.3	7.4	73.4
	58	FS2													-34.0	6.6	81.6
	59	JR1	2060 Y10R	0.01	0.28	0.60	0.39	0.66	1.74	5.33	2.47	11.5	>-7.5	27.2	-34.5	12.5	39.0
	60	JR2	5030 Y20R	0.73	7.46	6.47	10.87	7.15	10.53	60.51	62.49	166.2	(>-7.5)	50.8	-32.1	11.2	48.7
	61	PA1	1060 Y10R	0.00	0.07	0.19	0.75	2.21	8.15	11.28	11.05	33.7	-8.5	64.7	-30.9	9.1	59.9
	62	PA2	1070 Y10R	0.00	0.00	0.10	0.14	0.97	3.32	4.44	7.20	16.2	mon	88.3	-29.4	6.9	80.2
	63	TP1	2060 G90Y	13.14	82.52	48.26	24.33	16.83	30.21	97.29	60.75	373.3	>-7.5	36.1	-28.9	10.6	49.8
	64	TP2	3040 G70Y	0.00	0.00	0.82	7.38	15.87	39.53	9.04	30.15	102.8	-7.5	35.5	-31.6	16.3	32.1

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Table S2: Data acquired from one *F. sylvatica* sampled at about 10 m (bottom), 20 m (middle) and 30 m (top) above ground in Hölstein. leaf colour as NCS code, k(T): differential INP concentration. Duplicate measurements for leaf C and N displayed in separate rows.

dd/mm/yyyy	level	compass direction	NCS code	k(T) (cm^{-2} K^{-1})								INP$_{-10}$ (cm^{-2})	LMA (g m^{-2})	δ^{13}C (‰)	N (mg (g dry weight)$^{-1}$)	C:N atomic ratio
				-2.5	-3.5	-4.5	-5.5	-6.5	-7.5	-8.5	-9.5					
05/09/2023	top	N	4550 G50Y	0.00	0.00	0.00	0.05	0.10	0.80	0.92	1.14	3.0	97.6	-27.4	15.5	37.0
	top	S	5540 G40Y	0.00	0.00	0.00	0.03	0.08	0.36	0.47	2.25	3.2	99.0	-27.6	16.8	34.0
	middle	N	5540 G40Y	0.00	0.00	0.00	0.11	0.46	0.99	1.76	2.56	5.9	84.7	-29.2	18.6	30.6
	middle	N												-28.8	18.1	31.4
	middle	S	5040 G50Y	0.00	0.00	0.00	0.05	0.06	0.33	1.33	2.53	4.3	91.5	-28.5	20.2	28.6
	bottom	SE	5040 G40Y	0.00	0.00	0.24	11.68	20.47	19.55	17.58	3.56	73.1	73.5	-28.7	19.2	29.8
	bottom	N	5030 G30Y	0.00	0.00	0.00	0.10	0.50	0.97	2.39	3.81	7.8	47.8	-30.4	20.5	27.2
11/10/2023	top	N	1070 Y10R	0.00	0.00	0.02	0.06	0.10	1.00	1.90	1.64	4.7	84.5	-28.1	9.0	64.0
	top	S	1070 Y10R	0.00	0.00	0.02	0.02	0.24	1.13	1.81	3.83	7.1	97.8	-28.0	9.9	58.5
	middle	N	2070 Y10R	0.00	0.00	0.00	0.02	0.18	0.99	1.91	3.64	6.7	82.0	-28.9	9.5	60.3
	middle	S	1070 Y10R	0.00	0.00	0.00	0.04	0.24	0.90	2.02	2.56	5.8	84.0	-28.8	9.4	61.0
	bottom	N	3050 G80Y	0.00	0.00	0.00	0.10	0.34	1.40	3.79	1.57	7.2	79.1	-29.4	10.6	54.9
	bottom	SE	4050 G60Y	0.00	0.00	0.02	0.18	1.52	4.27	4.20	5.64	15.8	80.1	-28.7	17.4	32.2
														-28.6	18.1	32.2

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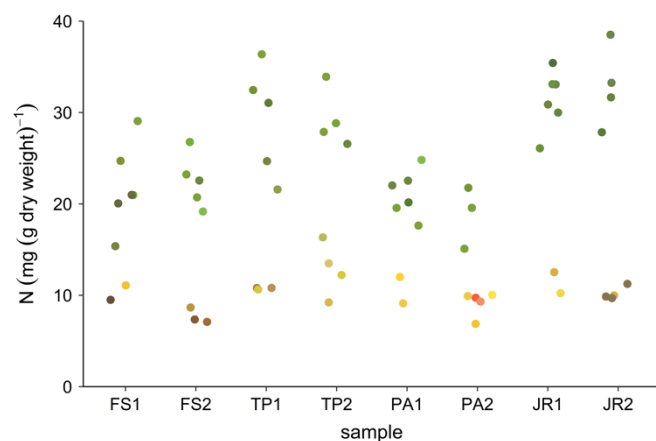
Figure S1: Nitrogen content of foliage from trees sampled in Gempen (FS: *F. sylvatica*, TP: *T. platyphyllos*, PA: *P. avium*, JR: *J. regia*). Colours display leaf colour.

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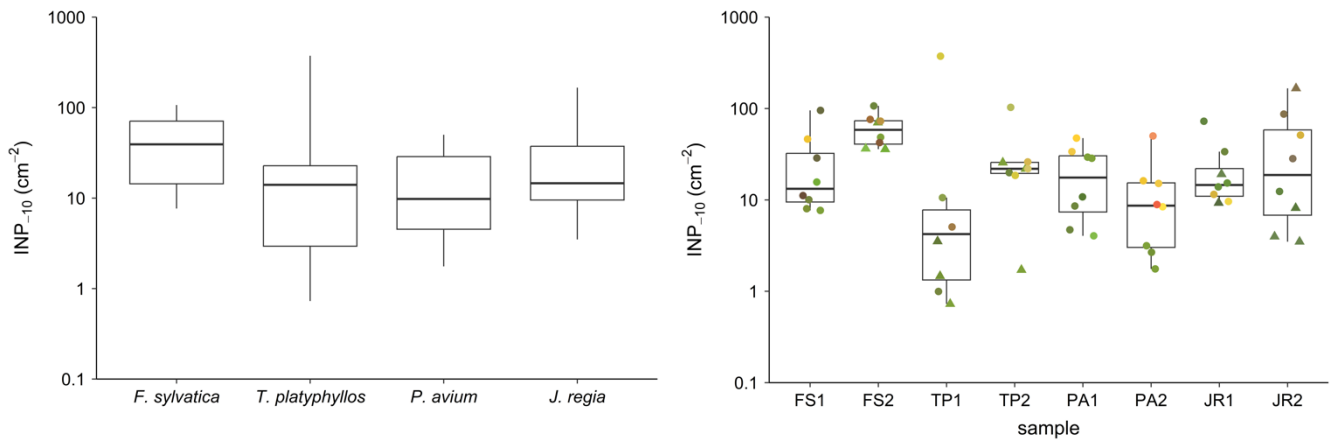
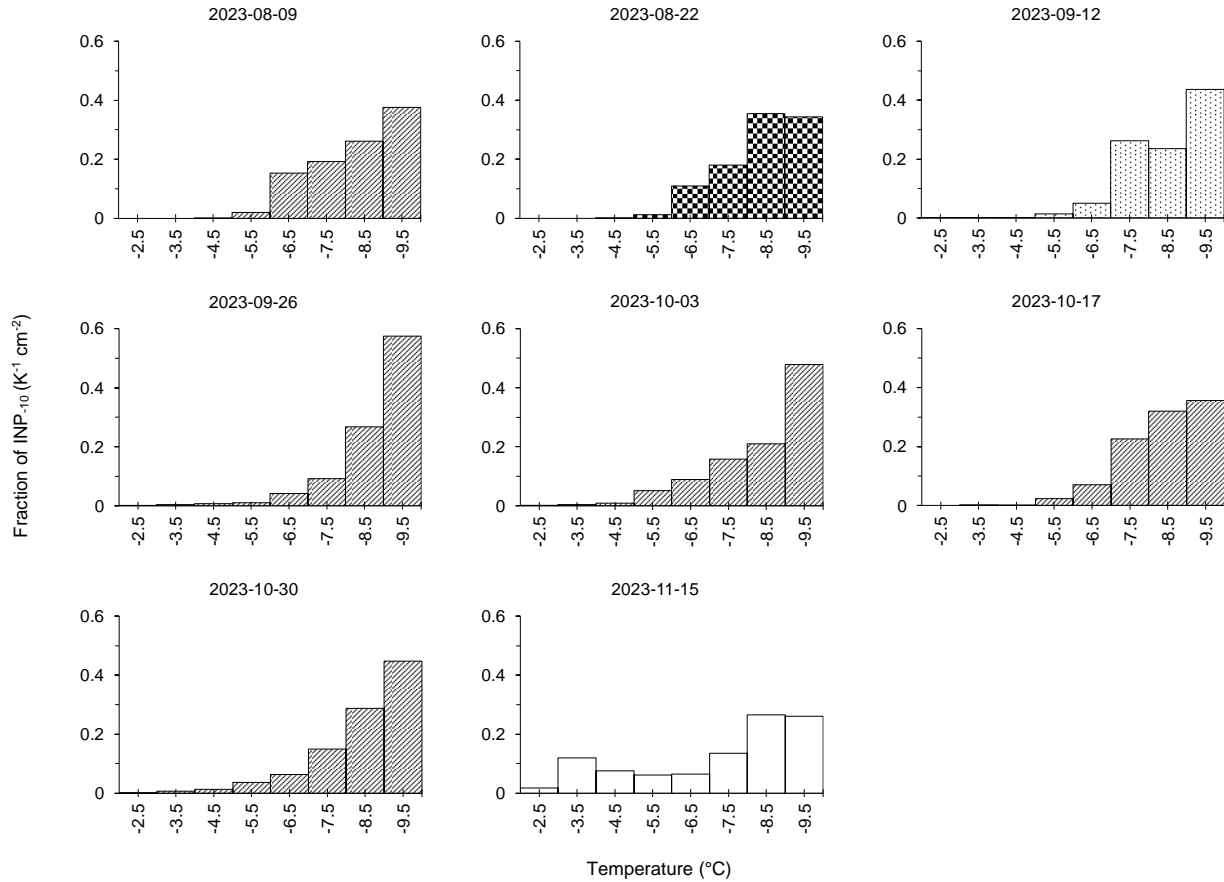


Figure S2: Cumulative concentration of INPs active at temperatures ≥ -10 °C (INP$_{-10}$) quantified in leaf washing water by species (left) and sampled tree (right) for the Gempen sampling site. Colours represent leaf colour, round symbols samples collected from the same tree.

2023-08-09	2023-08-22	2023-09-12
2023-09-26	2023-10-03	2023-10-17
2023-10-30	2023-11-15	

25 **Figure S3: Mean differential INP concentrations of all trees sampled on a particular day, normalized by total daily cumulative INP$_{-10}$ concentration.**